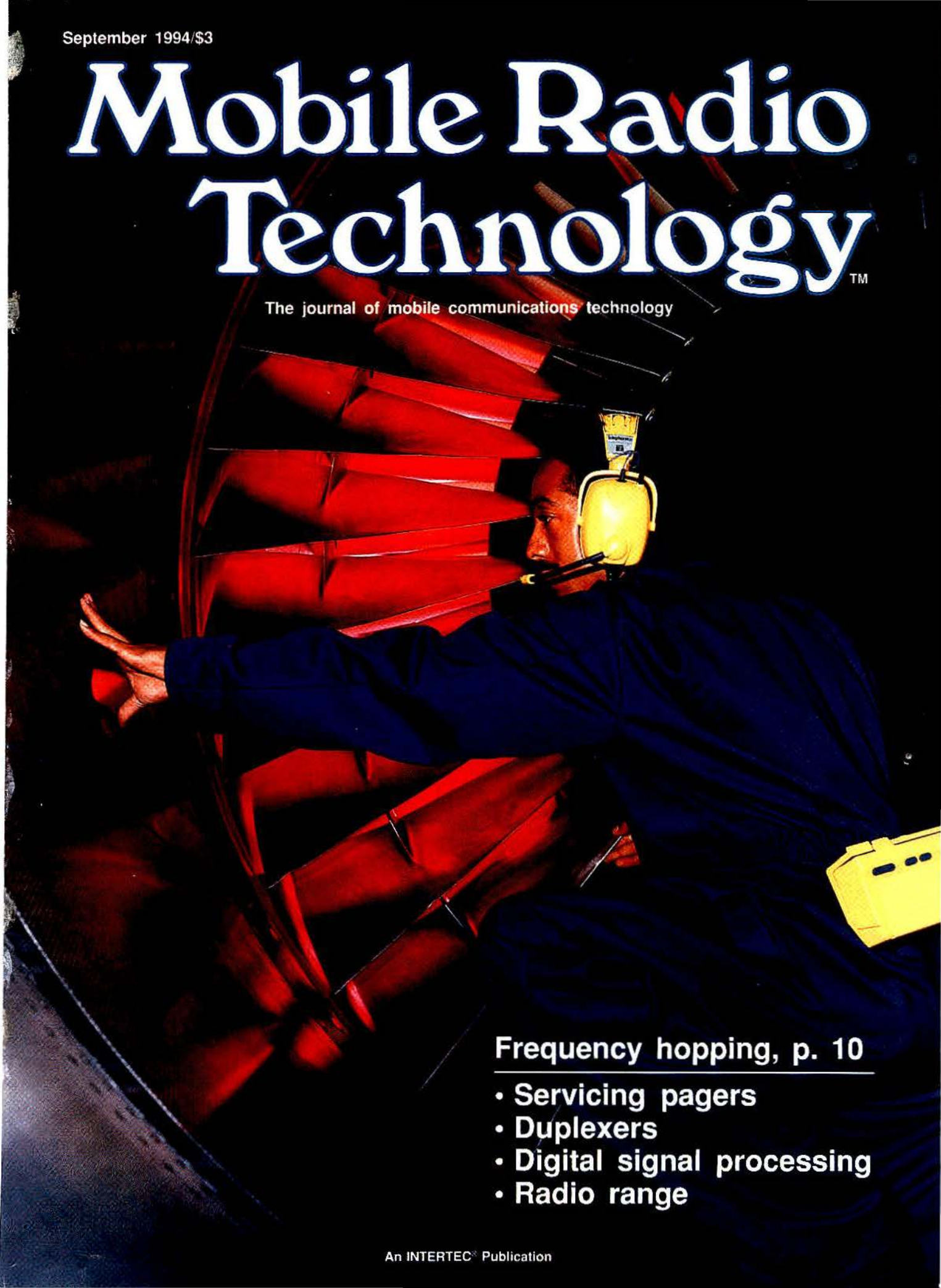
September 1994/$3

Mobile Radio Technology™

The journal of mobile communications technology



Frequency hopping, p. 10

- Servicing pagers
- Duplexers
- Digital signal processing
- Radio range

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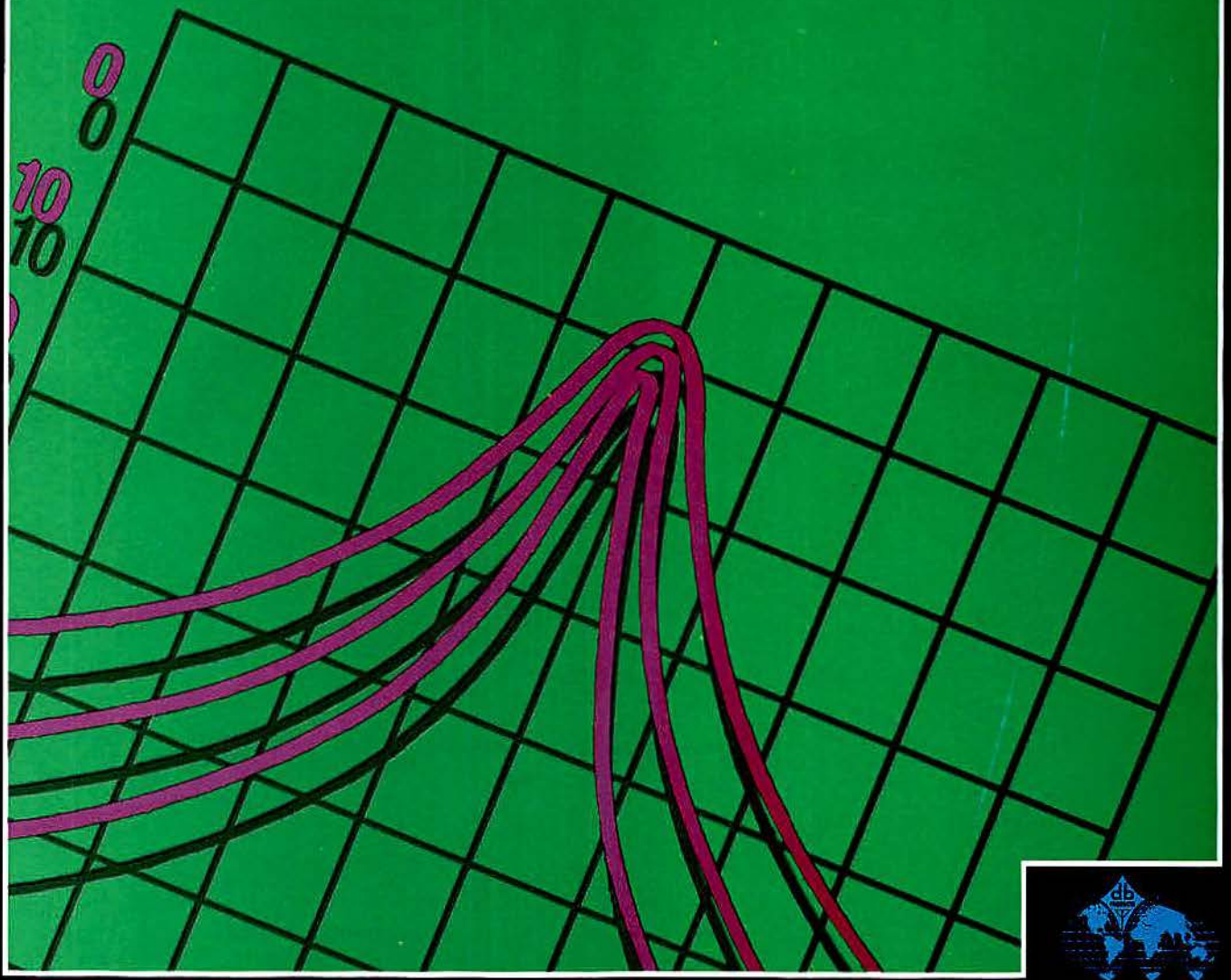

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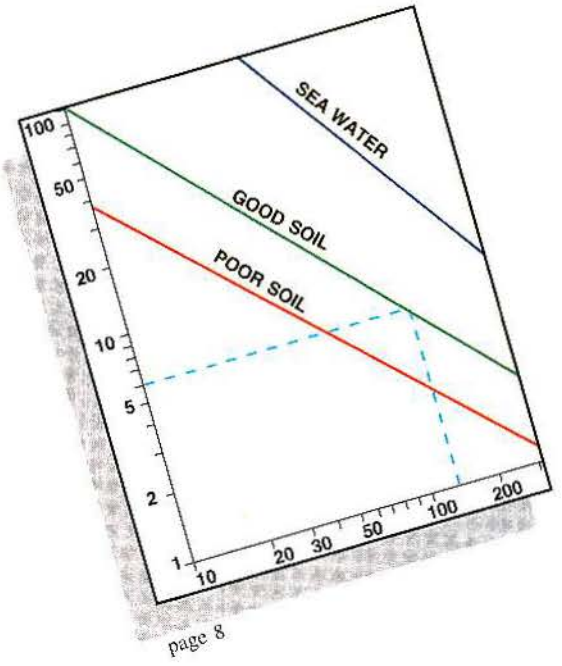

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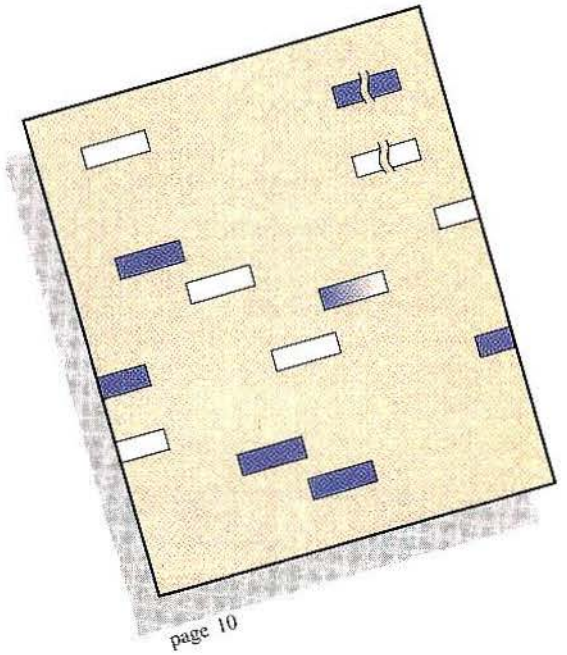

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features

On the cover: An aircraft maintenance technician with a wireless communications headset inspects a jet engine inlet. See Michael Donovan's article on page 10. *Photo courtesy of Telephonics Communications Systems Division, Instrument Systems, Huntington, NY.*

departments

Mobile Radio Technology (ISSN 0745-7626) is published monthly by Intertec Publishing Corporation, 9800 Metcalf, Overland Park, KS 66212-2215, and mailed free to qualified persons within the United States and Canada. Second-class postage paid at Shawnee Mission, KS, and additional mailing offices. POSTMASTER: Send address change to Mobile Radio Technology, P.O. Box 12960, Overland Park, KS 66282-2960.

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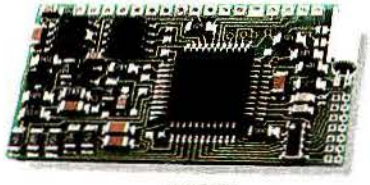

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Scanning . . .

Communications privacy

The Electronic Communications Privacy Act of 1986 and subsequent law that bans the sale of scanning receivers that tune cellular telephone frequencies are bad laws. Privacy should be obtained by scrambling the transmission, not by outlawing receiving equipment and its use.

During the Surveillance Expo '94 to be held Aug. 8–12 in McLean, VA, American Technology Associates and Ross Engineering will demonstrate how legal equipment can accomplish what lobbyists, legislators and FCC regulation-writers tried to prevent: reception on cellular mobile telephone frequencies.

Three legal types of equipment will be used to monitor transmissions on cellular frequencies. One of the demonstrations will use a cellular telephone as the scanner. It isn't possible to ban cellular telephones without putting the cellular companies and their lobbyists out of business.

The law restricting reception on cellular frequencies is on the books, but it should be rescinded.

* * *

Private carrier paging

Despite many years' worth of predictions that the 20% annual growth in the number of paging subscribers would slow, it hasn't.

Dominated by common carrier licensees with exclusive frequency assignments to serve geographic areas, the paging industry began running out of frequencies to use when individual systems reached capacity.

At the same time, the common carriers were challenged by upstart private carrier paging licensees that attracted many of the same kinds of customers. Private carrier systems were assigned non-exclusive frequencies, meaning that as their subscriber numbers grew, competing systems shared the same frequencies in their common service areas.

An outrageous few common carriers fought the private carriers by causing intentional interference on private carrier frequencies. Others, rather than fight the private carriers, joined them, by using private carrier licenses of their own to expand their service capacities.*

Maybe it is a sign of the old-line common carriers having obtained enough private carrier customers to run the show, but the FCC now is being asked to permit exclusive frequency assignments for private carrier paging systems in the VHF and UHF bands. Windows of opportunity open and close, and it looks as though the opportunity for small businesses to start private carrier paging systems may be about to close.

* * *

PCS paging

One incarnation of personal communications services (PCS) is going to be another paging service, one that includes confirmation of message receipt. Not unexpectedly, many of the current large common carrier-private carrier paging system licensees are PCS license applicants.

They have to buy their way in, because these PCS paging frequencies (officially called *narrowband PCS*) are to be sold to prospective licensees at auction.

Telecommunications service providers constantly look for ways to add value to their services to keep subscriber prices above commodity levels. The "cheap beep" commodity pricing of one-way numeric paging might be overcome by acknowledgement paging, at least until acknowledgement paging becomes prevalent.

The prospect for higher margins on acknowledgement paging and access to more frequencies could make the auction especially competitive. Many current licensees view PCS licenses as the key to future growth.

* * *

Utilities as competitors

Legislation working its way through Congress may free electricity, water and gas utilities to sell radio communications services to the public.

Many utilities have extensive trunked and conventional private radio communications networks. With authority to sell network access to other users, utilities could enter into competition with specialized mobile radio (SMR), community repeater and private carrier system operators.

Maybe this has some logic to it. If enough SMR systems are converted to digital cellular telephone systems, they may carry such a financial burden that they could no longer price dispatch service competitively. Private networks-turned-into-public networks might fill a need.

Utilities are accustomed to heavy regulation, so maybe the prospect of the common carrier regulation of their communications networks that probably would follow such a conversion would not deter them. It is too early to tell. We saw no special enthusiasm for the idea at June's Utilities Telecommunications Council conference, but then, we're only talking about pending legislation.

* * *

Spectrum reallocation

We're pleased to see private radio network operators take an agressive posture in responding to the reallocation of 200MHz of government spectrum to the private sector.

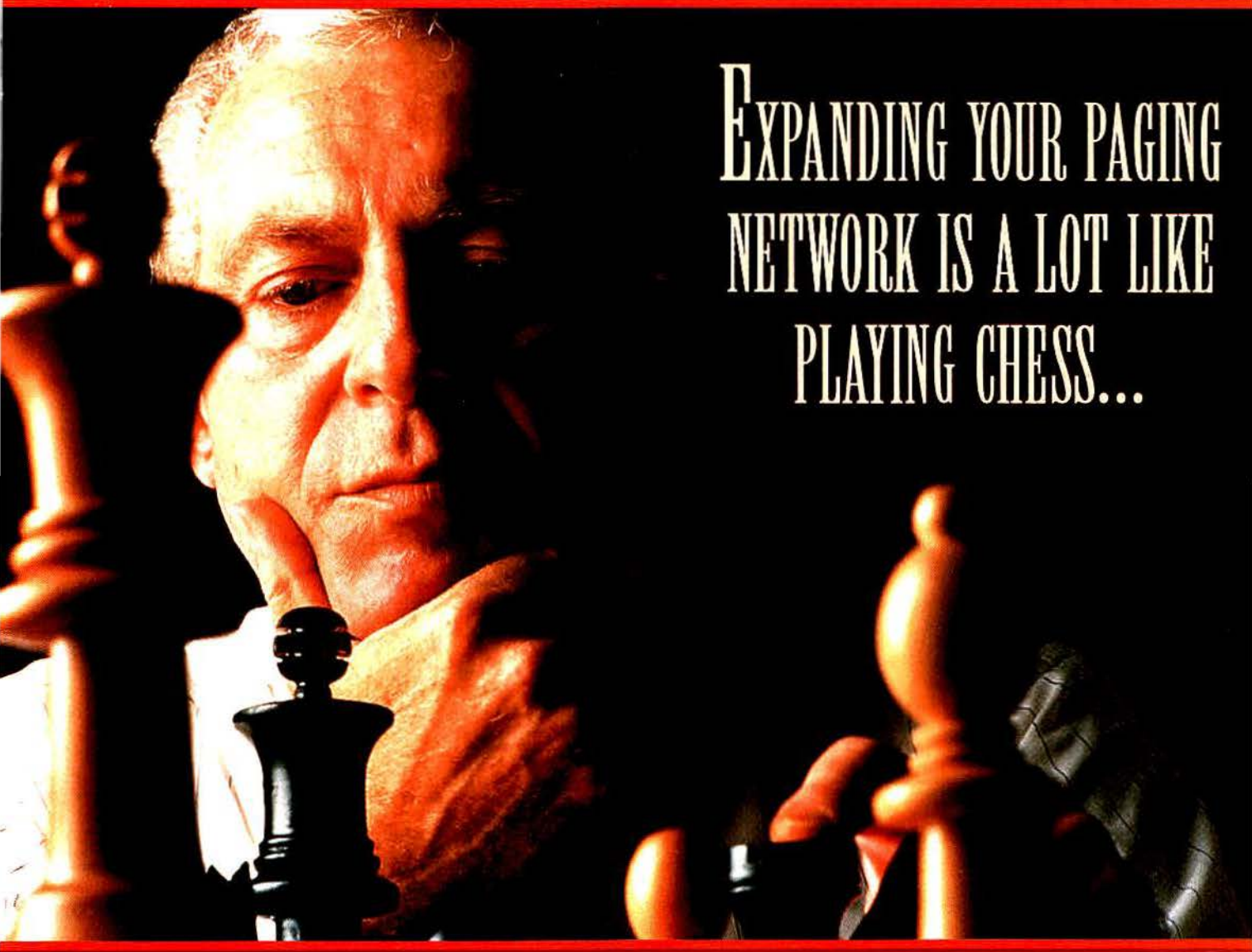
Led by public safety agencies and utility companies, private users are asking for at least 75MHz of spectrum because, among other reasons, public systems such as cellular, specialized mobile radio and personal communications services networks will not be adequate to meet expansion requirements for private networks.

In addition, the spectrum would be used for advanced technologies that use digital signal processing, imaging and compression.

The "one size fits all" approach of the public networks cannot satisfy all mobile communications users, and the private users' requirements deserve to be met.

—Don Bishop

*A few system operators strayed out of bounds here, too, by using their private carrier frequencies to serve some of their common carrier subscribers who, according to FCC rules, were ineligible to receive service from a private carrier.



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...you have several options, but some choices make more sense than others.

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What's the best way to link your transmitter sites? You've played this game awhile, so you know your options. In the last few years, satellite technology has come to the forefront as one of the most cost-effective methods of linking transmitter sites.

More paging networks than ever before are now using satellite control links. **In fact, 7 of the top 10 paging networks currently use satellite technology from SpaceCom Systems.**

Plus, a long list of smaller regional operations are using SpaceCom's satellite technology to link as few as four transmitter sites. Why? Because they've considered the options, crunched the numbers, and realized that SpaceCom's satellite technology was the best long-term business decision for their paging network.

And with PCS looming on the horizon, your network must be ready to keep pace with the industry. SpaceCom's technology allows you to easily upgrade data rates and add new services. And stay ahead of your competition.

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Calendar

September

22-24—Personal Communications Showcase, sponsored by the Personal Communications Industry Association (PCIA), Washington State Convention Center, Seattle. Contact: 800-326-8638.

27-Oct. 1—International Conference on Universal Personal Communications, sponsored by the Institute of Electrical and Electronics Engineers, Hyatt Regency San Diego, San Diego. Contact: Nokia Mobile Phones, 800-306-6542.

October

3-5—WirelessWorld Conference & Exhibition, sponsored by *Cellular Business* magazine, The Stouffer Orlando Resort, Orlando, FL. Contact: Chris Lotesto, 800-458-0479.

19-21—International Wireless Communications Expo/Fall, Tampa Convention Center, Tampa, FL. Contact: 800-828-0420.

26-28—Manufacturers Radio Frequency Advisory Committee (MRFAC) fall meeting, Hotel Gettysburg, Gettysburg, PA. Contact: Stephen Kress, 703-318-9206.

November

3-5—Industrial Telecommunications Association and Council of Independent Communication Suppliers Annual Meetings, The Kingsmill Resort and Conference Center, Williamsburg, VA. Contact: Barbara J. Levermann, 703-528-5115.

10-13—Communications Marketing Conference, sponsored by the Communications Marketing Association, Radison Plaza Lord Baltimore Hotel, Baltimore, MD. Contact: Jack Armstrong, 410-628-9300.

18—Radio Club of America, Communications Symposium, 85th Anniversary Dinner and Awards Presentation, New York Athletic Club, New York: Contact: Ron Formella, 201-652-6811.

December

6-8—Wireless Datacomm Fall, Washington Convention Center, Washington, DC. Contact: 800-322-9332.

1995

February

1-3—Cellular Telecommunications Industry Association Winter Meeting and Exposition, New Orleans. Contact: 202-785-0081.

March

TBA—Government Land Mobile Communications Conference, sponsored by TMSA Conferences, Washington, DC. Contact: Steven Silver, 310-534-4871.

13-14—AMTEX, the American Mobile Telecommunications Association's Marketing and Technology Conference and Exposition, The Buttes, Tempe, AZ. Contact: 202-331-7773.

20-23—Supercomm, sponsored by USTA and TIA, Anaheim Convention Center, Anaheim, CA. Contact: 202-326-7300.

April

3-5—Energy Telecommunications and Electrical Association, George R. Brown Convention Center, Houston. Contact: 214-235-0655.

25-27—International Wireless Communications Expo/Spring, Las Vegas Sands Convention Center, Las Vegas. Contact: 800-828-0420.

May

17-19—Mobile Communications Conference, sponsored by the National Association of Business and Educational Radio (NABER), Hotel del Coronado, San Diego. Contact: Nancy Palleschi, 800-759-0300.

30-June 2—Radiocomm, Toronto Metropolitan Convention Center, Toronto. Contact: 613-233-4888.

July

26-28—Vehicular Technology Conference, sponsored by IEEE Vehicular Technology Society, Hyatt Regency Chicago O'Hare, Chicago. Contact: Keith Paglusch, chairman, 312-399-2378.

August

13-18—Association of Public-Safety Communications Officials—International National Conference, Detroit. Contact: 800-949-2726.

September

20-23—Personal Communications Showcase, sponsored by the Personal Communications Industry Association (PCIA), Orange County Convention Center, Orlando, FL. Contact: 800-326-8638.

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The journal of mobile communications technology

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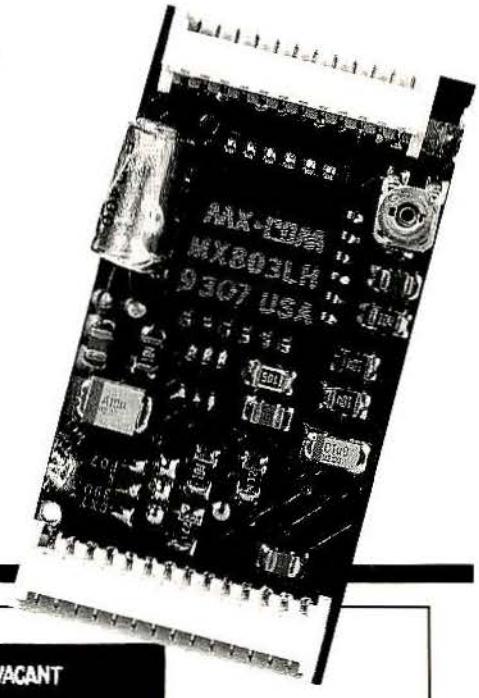

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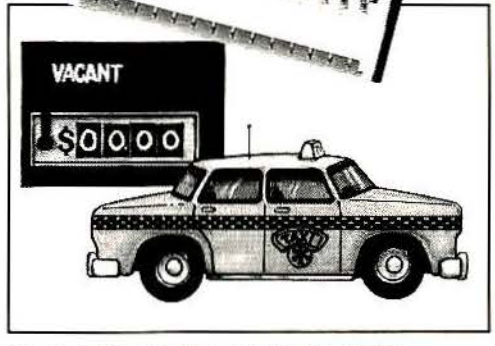

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Estimating radio range

By Harold Kinley, C.E.T.

Many variables go into the formula for calculating radio coverage area or range. Unlike free-space propagation, no simple formula fits every situation for plane-earth propagation. Of particular importance in estimating or calculating radio coverage is the terrain itself or the "lay of the land." In this column we will look at a series of range prediction graphs based on the modified Egli model—a formula found in Edward Singer's book, *Land Mobile Radio Systems* (Prentice-Hall, 1989).* This book is highly recommended for anyone working in land mobile radio.

* This book is now in its second edition, published in 1994.

Kinley is a certified electronics technician with the South Carolina Forestry Commission, Spartanburg, SC. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, Prentice-Hall, 1985.

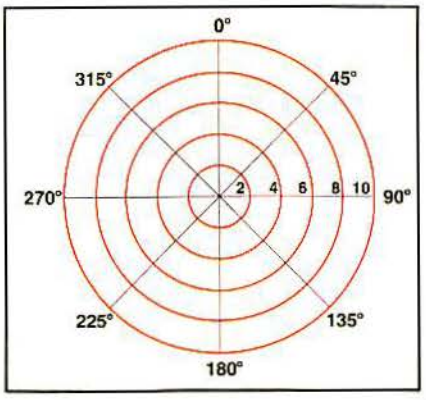


Figure 1. The intersections of cardinal radials from a tower site and concentric circles of a set increment are used as sampling locations for determining height above average terrain (HAAT).

Before describing the use of these graphs, let's cover a few topics that you should know and understand to better use the graphs.

Effective base antenna height

To calculate the "effective" antenna height or height above average terrain (HAAT) for a base antenna, three figures must be known or computed:

(1) the height of the antenna above ground level (AGL).

(2) the elevation of the tower site above sea level (ASL).

(3) the average terrain elevation above sea level.

To calculate the average terrain elevation, you must know the elevation at the tower site and at 40 points surrounding the tower site. Figure 1 at the left shows the required locations where the elevation must be known. The center is the tower site location. Notice that there are eight radials extending from the center to a point 10 miles out. These radials begin at 0° and are spaced 45° apart. They are known as the *cardinal* radials. Concentric circles at two-mile increments are drawn around the center point, with the outer circle being at a distance of 10 miles from the tower or center. At each point where a radial intersects a circle, the elevation must be determined.

(continued on page 46)

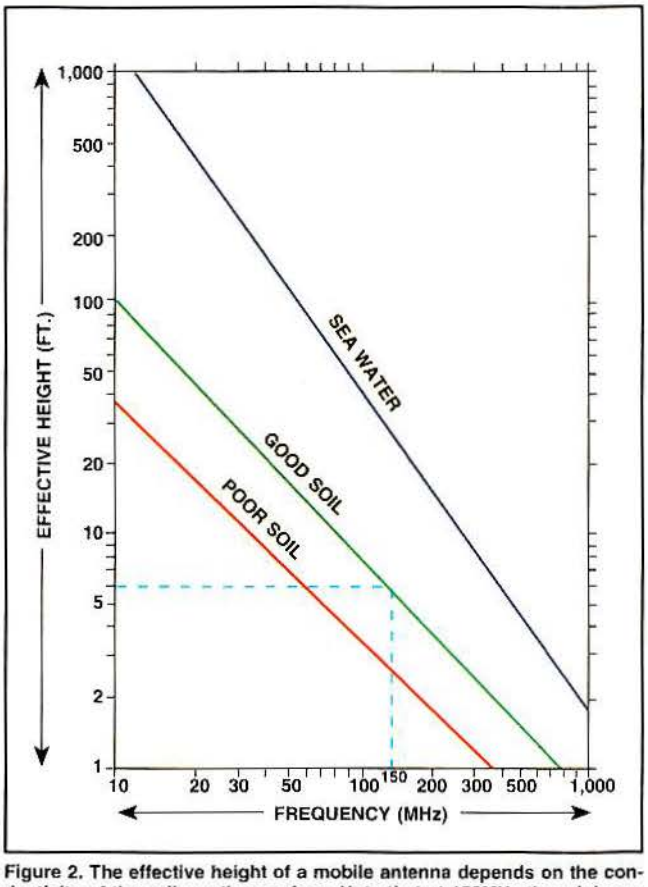


Figure 2. The effective height of a mobile antenna depends on the conductivity of the soil or other surface. Note that at 150MHz the minimum effective height is approximately 6 feet.

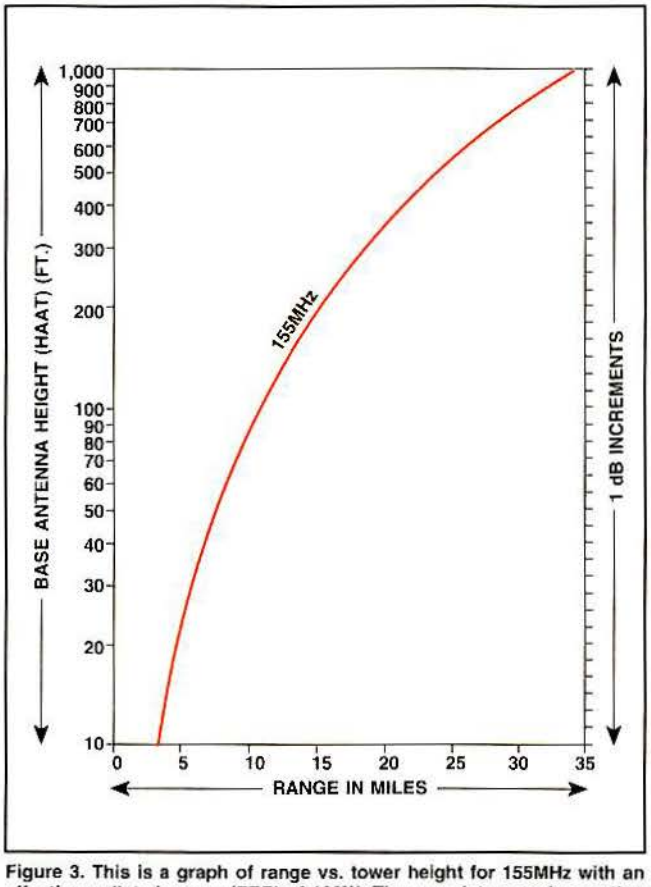
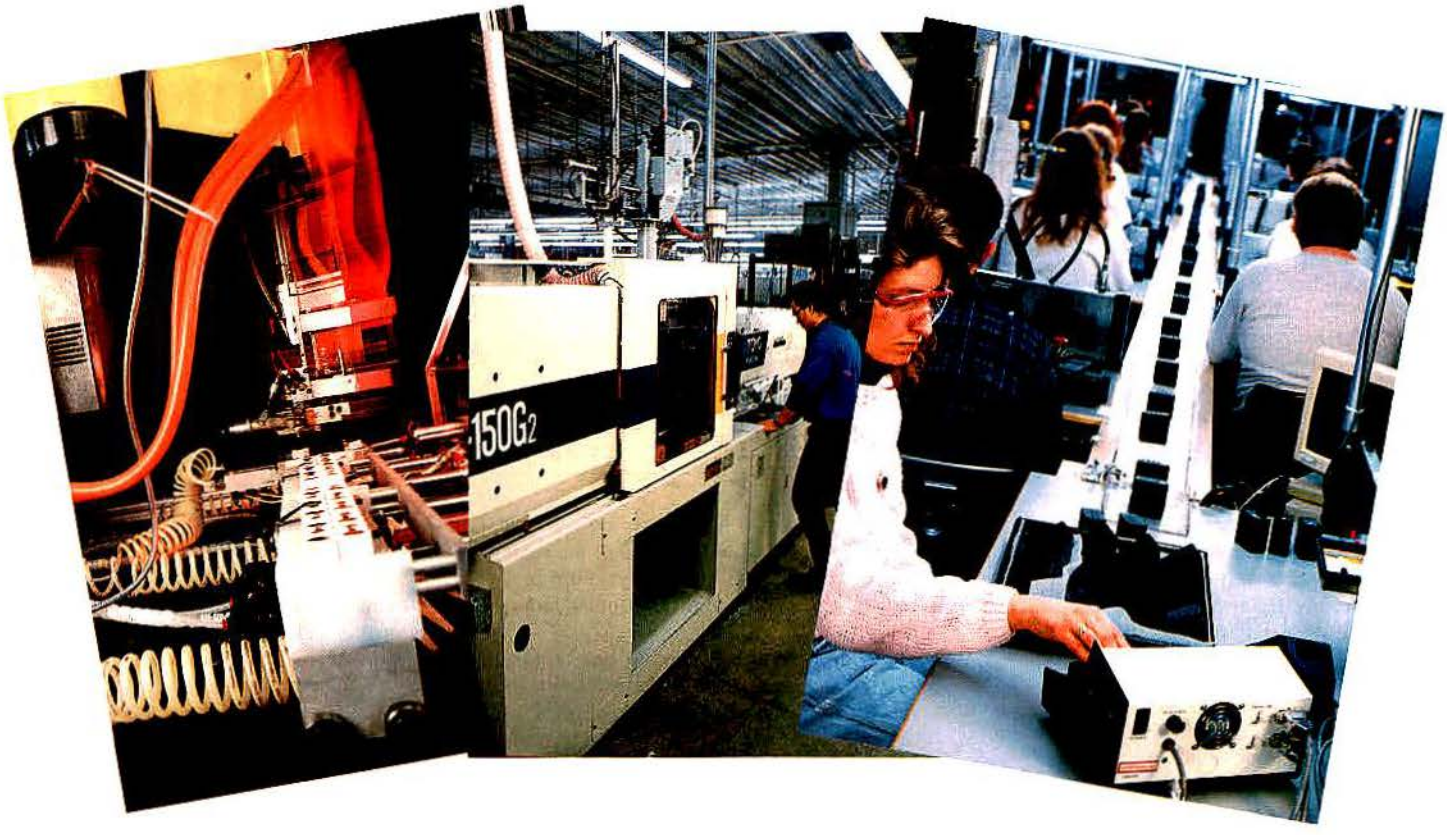


Figure 3. This is a graph of range vs. tower height for 155MHz with an effective radiated power (ERP) of 100W. The complete set of operating characteristics is: ERP = 100W; gain of mobile antenna = −1dBd; receiver line loss = 1.5dB; noise degradation = 3dB; receiver antenna height = 6 feet; probability of communication = 90%.

A Powerhouse.



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Circle (8) on Fast Fact Card

Frequency hopping supports wireless headset system

Designed for high-noise airport environments, frequency-hopping wireless headsets offer duplex and simplex choices, telephone interconnect and compatibility with wired intercom systems.

By Michael Donovan

People standing on the airport tarmac are deaf to anything except the roar of aircraft engines. A shout, or even a scream, goes unheard in the din.

With wireless communications, aircraft push-back team members can talk naturally and easily hear and understand one another.

A combination headset and two-way radio provides short-distance, full-duplex team communications. It uses software controls to ensure reliable communications despite radio fading or high-level RF in-band traffic. The system uses the 902MHz–928MHz band and frequency-hopping modulation for privacy.

Though secure communications is not the primary concern in aircraft support applications, frequency hopping allows multiple teams to use the same frequency spectrum without interference. Team members with a common frequency hopping code (Team A) can speak freely with one another. Another team (Team B) using the same system, but with a different frequency-hopping code, can communicate only with their own team members. Neither Team A nor Team B will interfere with, or receive interference from, the other team, even if both teams are working in the same area. All radios are of the same configuration and, by simply entering a code, users can network with other radios using that same code.

In addition, the radios do not require FCC licensing. This virtually eliminates the normal airport-related problems of overcrowded radio bands and overpowering radio transmitters.

The system architecture, shown in block diagram form in Figure 1 below, provides full-duplex communications. For example, radio number 1 transmits on F1 and receives on F2; radio number two transmits on F2 and receives on F1. Radio number 1 in the system acts as a repeater for the signal it receives from radio number 2, in addition to adding its own audio to the transmitted signal. In this manner, audio

Donovan is director of marketing, Telephonics Communication Systems Division, Instrument Systems, Huntington, NY.

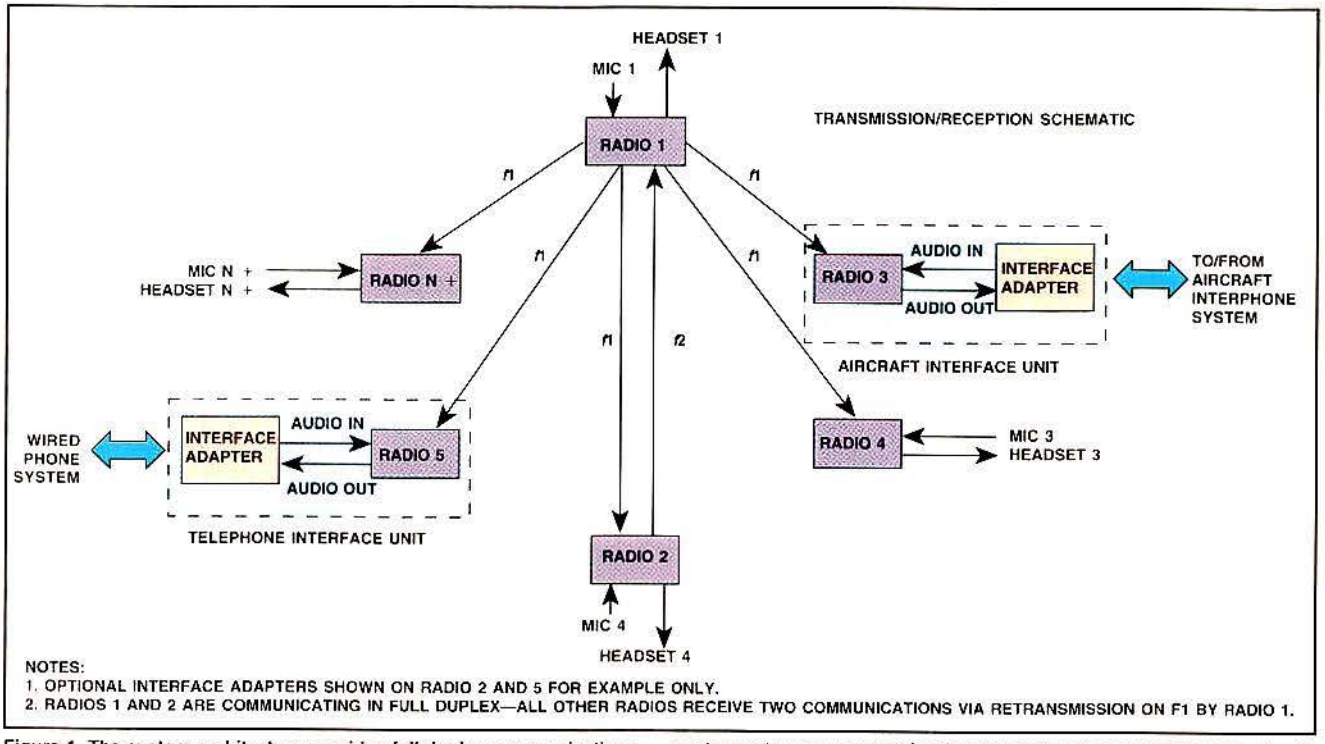

Figure 1. The system architecture provides full-duplex communications. For example, radio number 1 transmits on F1 and receives on F2; radio number two transmits on F2 and receives on F1. Radio number 1 in the system acts as a repeater for the signal it receives from radio number 2, in addition to adding its own audio to the transmitted signal. In this manner, audio from a radio is repeated to all units on the same frequency net.

An aircraft maintenance technician inspects a jet engine inlet while wearing a wireless communications headset to communicate with co-workers.

audio from a radio is repeated to all units on the same frequency net.

The radio uses a dynamic configuration algorithm to simplify and to speed up system initialization.

During dynamic configuration, a radio that has just been turned on scans for other radios in its group. It determines which frequency slots are open and assigns itself to that slot. With this process, audio integrity is maintained.

Frequency plan

The frequency plan is depicted in Figure 2 below. The 902MHz–928MHz band was chosen because Paragraph 247 of FCC Part 15 allows unlicensed communications in this band with maximum transmission power of 1W. The radio meets this limitation.

The radio works reliably at distances as great as 500 feet in low-power mode and as great as one mile in high-power mode. Regardless of predicted range, reflectors, walls, water and indoor operation may affect the distance over which the system performs.

Advantages to the full-duplex configuration include:

□ *Mobility* — The group does not have to be co-located with a fixed base station.

□ *No base station* — Operation without a base station reduces system cost and improves communications reliability.

□ *Full-duplex communications* — Team members can speak and listen simultaneously.

□ *Number of users* — An unlimited number of users may be assigned in a given group.

□ *Change tolerance* — Working radios tune around a radio that has been turned off.

Simplex operations architecture

The system also provides a frequency hopping simplex mode for use when full duplex is not required. The simplex architecture is shown in Figure 3 on page 12. Each radio in the system transmits one at a time. With this architecture, an unlimited number of users can communicate on the same frequency net. Simplex is identical in operation to most "walkie-talkie" radios, and requires standard radio protocol to communicate efficiently.

The simplex frequency plan is shown in Figure 2. The radios operate on the first frequency of each channel (i.e., 902.000MHz, 902.175MHz, 902.350MHz, etc.), providing 128 channels to operate on.

Advantages to the simplex configuration include:

□ *Spectrum efficiency* — Only one transmit and receive frequency is required.

□ *Mobility* — The group does not have to be co-located with a fixed base station.

□ *Number of users* — An unlimited number of users may be assigned in a given group.

Frequency hopping

Both the full-duplex and simplex modes use frequency hopping for confidential communications. Frequency hopping is a

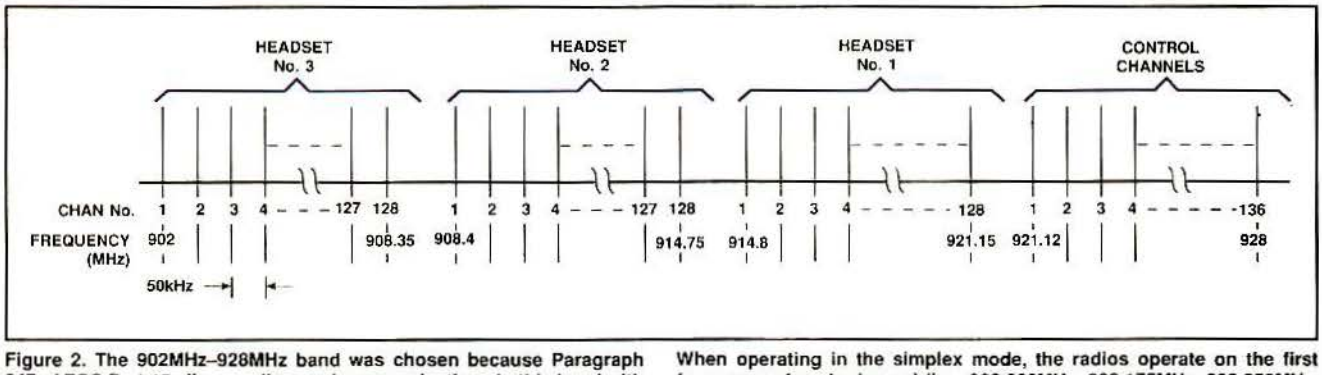

Figure 2. The 902MHz–928MHz band was chosen because Paragraph 247 of FCC Part 15 allows unlicensed communications in this band with maximum transmission power of one watt. The radio meets this limitation and uses channels according to the frequency plan shown above. When operating in the simplex mode, the radios operate on the first frequency of each channel (i.e., 902.000MHz, 902.175MHz, 902.350MHz, etc.), providing 128 operating channels.

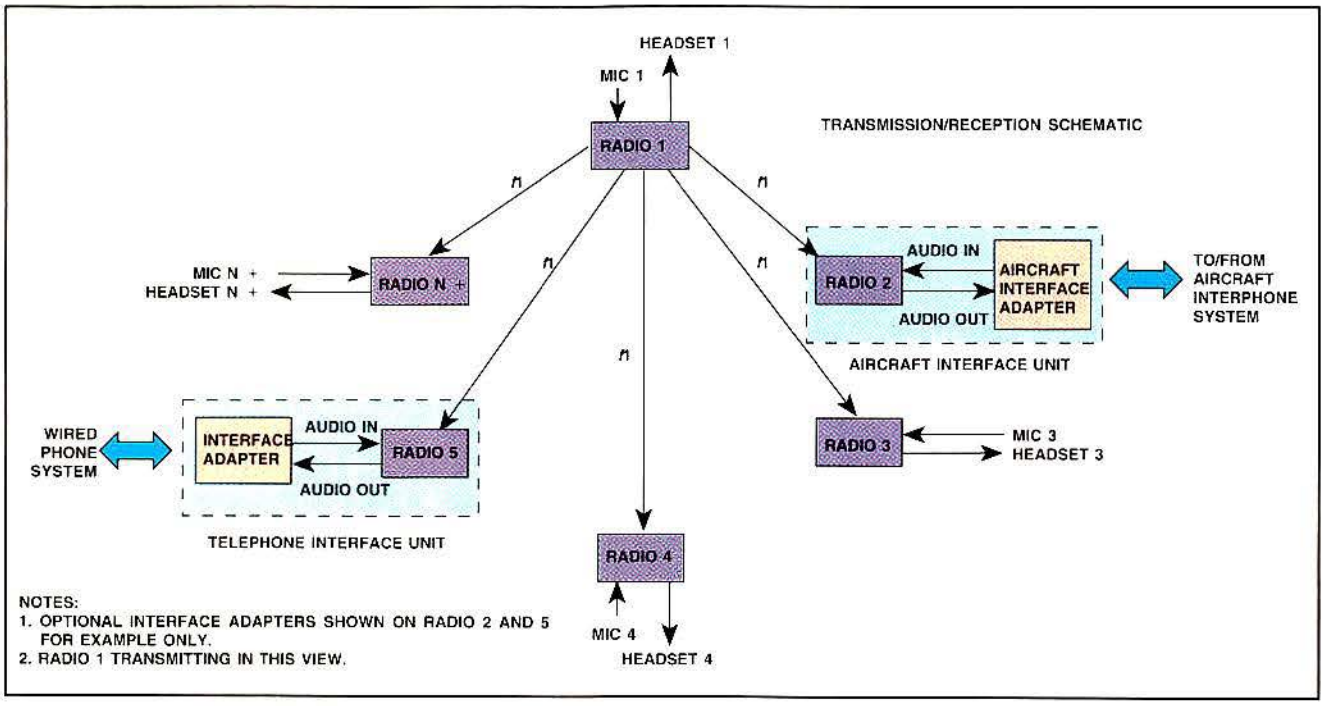

Figure 3. The system provides a frequency-hopping simplex mode for use when full duplex is not required. Each radio in the system transmits one at a time. With this architecture, an unlimited number of users can communicate on the same frequency net. Simplex is identical in operation to most "walkie-talkie" radios, and requires standard radio protocol to communicate efficiently. The simplex frequency plan is shown in Figure 2.

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spread-spectrum technique in which a radio's transmitter and receiver periodically retune (hop) to new frequencies to avoid detection or interference.

The pattern over which the radios hop is determined by a pseudo-random code generator. The length of the pseudo-random code, the hop rate and the number of available frequencies over which the radio can hop all determine the susceptibility to detection or interference. Given its operating characteristics, the wireless headset system is classified as having a low probability of intercept (LPI).

Frequency-hopping systems require all radios in the system to hop together. Communications will be lost if any radio in the system is on a frequency different than others in its group. To maintain synchronization, the radios use a highly stable time base and exchange data among themselves.

Initial acquisition (entry into the net) is accomplished by a proprietary software algorithm, along with data transmission at preselected net-dependent frequencies. Acquisition can take as much as three seconds, depending on the operating scenario. (See Figure 4 on page 16.)

Aircraft interface unit

Of interest to the air transport industry is the ability to use the wireless headsets to communicate with an aircraft flight deck.

Frequency-hopping systems require all radios in the system to hop together.

Currently, the ground crew or mechanics use a hard-wired headset and cannot move beyond the length of the cable. With an aircraft interface unit, the aircraft becomes a member of the wireless headset group. Flight crews or mechanics in the cockpit can communicate with anyone wearing a wireless headset and operating on the same code (net) anywhere in or around the aircraft. The benefit of quick, accurate communication to or from the flight deck enhances the efficiency and safety of these operations.

Acoustics

In many cases, wireless headset users work in a high-noise environment. Typical noise levels within 100 feet of a taxiing aircraft can exceed 110dB sound pressure level (SPL). Unattenuated noise at these levels poses several concerns:

(1) hearing damage.

(2) Noise picked up by a standard microphone is transmitted, thus competing with user's voice signal.

(3) Received audio signals must compete with noise "leaking" into standard earcups.

The wireless headsets tackle these problems with a combination of acoustical and electrical innovations. High-efficiency earphones mounted in large-volume earcups (high-noise environment headset) provide high sound levels to the ears at minimal power drain. The earcup cushions provide a tight, uniform seal around the ears to prevent external noise from leaking in. In addition, a noise-canceling microphone, specially designed for the noise typically found around aircraft, is the heart of the

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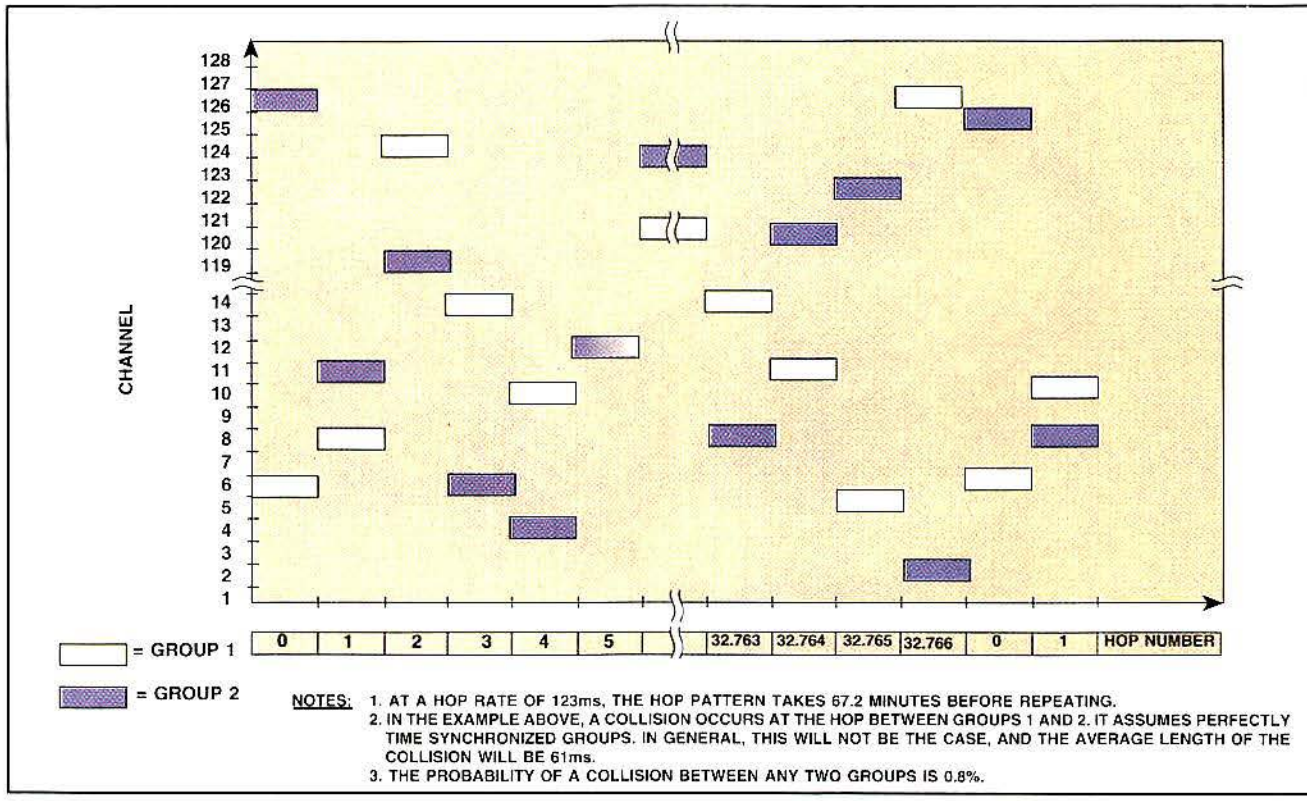

Figure 4. Frequency-hopping systems require all radios in the system to hop together. Communications will be lost if any radio in the system is on a different frequency from others in its group. To maintain synchronization, the radios use a highly stable time base and exchange data among themselves. Initial acquisition (entry into the net) is accomplished by a proprietary software algorithm, along with data transmission at preselected net-dependent frequencies. Acquisition can take as much as three seconds, depending on the operating scenario.

acoustic system.

The most critical items for working "hands-free" in a high-noise environment are the noise canceling microphone and the voice-operated transmission (vox) circuitry. Typically, this is where most radio systems fail to live up to expectations. The wireless headsets incorporate an automatic vox technology developed for use in high-noise military applications. The automatic vox circuitry senses the outside noise level, automatically separates it from voice energy and adjusts the vox threshold. There are no manual adjustments and no "falsing" to contend with. Automatic vox has been proven to work around Boeing 727, DC-10, MD-80, MD-11, and various military cargo and bomber aircraft.

Phone function

The wireless headsets can be configured to access a wired telephone system or to receive a call from a telephone user.

A telephone interface unit (TIU) includes a full-function frequency-hopping radio connected with the telephone system. Using the phone key, a phone number can be called via the TIU to connect with the telephone system. The TIU handles outgoing and incoming calls in full-duplex and simplex modes.

Page function

A page function allows the group to advise an area supervisor to join the group with a tone and a numerical display of the group's net number. The supervisor may access the group by entering the group's net number, thus providing a prompt management interface.

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Bob Wendt, Manager
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Servicing pagers: 150MHz receivers

Part 9—Here are some details about the inner workings of VHF Bravo receiver circuitry. Tips are included for changing pager frequencies for alignment purposes and other applications.

By David Ludvigson

To this point we have discussed Motorola Bravo receiver boards for the 929MHz–932MHz and 406MHz–512MHz frequency ranges.

The following information applies to the NRD7211–NRD7217 150MHz receivers that cover 138MHz–174MHz.

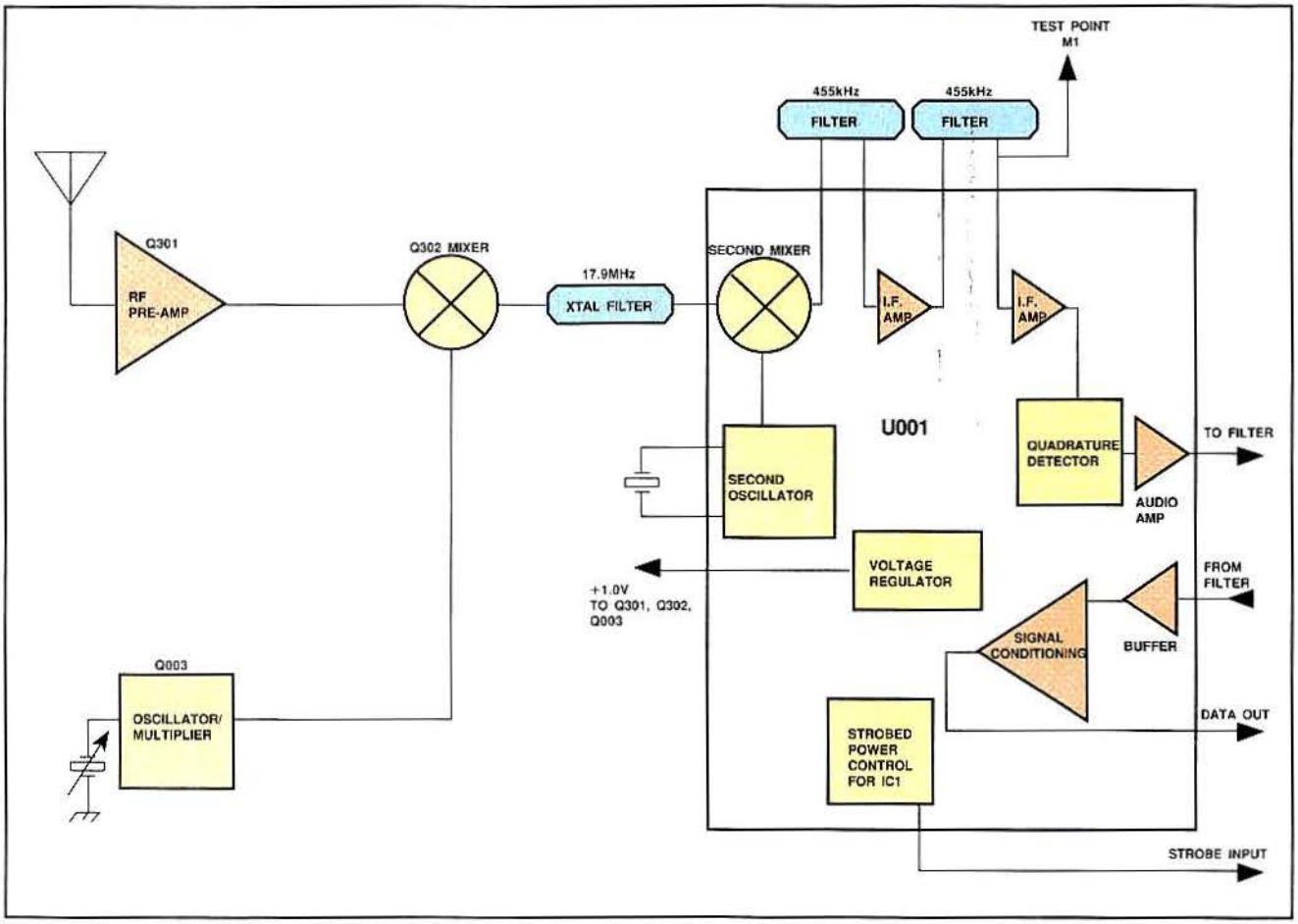
NRD receiver boards cover:

FREQUENCY RANGE (MHz)	MODEL NO.
138 – 143	NRD7211A,B
143 – 148.6	NRD7212A,B
148.6 – 152	NRD7213A,B
152 – 159	NRD7214A,B
159 – 164	NRD7215A,B
164 – 169	NRD7216A,B
169 – 174	NRD7217A,B

This particular series of boards is a mixed bag of tricks.

Figure 1 below is a block diagram of the NRD series receivers. (For additional detail, refer to the schematic diagram in the pager manual.) The first IF is 17.9MHz, and the second conversion oscillator may be either 17.445MHz or 18.355MHz. To

Ludvigson is a technician in Houston.



A block diagram of the NRD series 138MHz–174MHz receiver. See text for oscillator/multiplier details.

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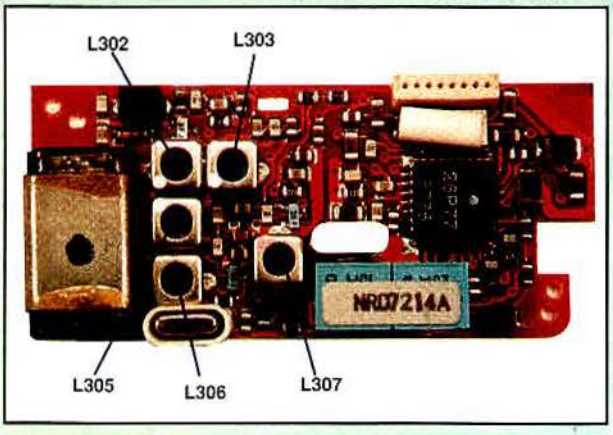
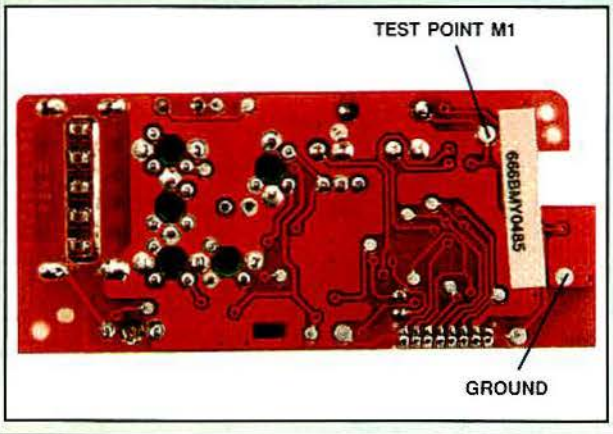
SMR 10 MHz BAND	48569-N	851-869
900 MHz SMR FULL BAND	48522-N	935-941
BASIC CELLULAR A BAND	48549-N	869-891.5
ENHANCED CELLULAR A BAND	48550-N	869-891.5
BASIC CELLULAR B BAND	48543-N	880-894
ENHANCED CELLULAR B BAND	48551-N	880-894

Alignment procedure: Bravo NRD series (17.9MHz IF)

The following procedure deviates somewhat from the suggested Motorola technique, and assumes the use of a shielded room (See Part 1) and the IFFER (See Part 2).

1. Set the signal generator to the exact frequency of the receiver. See text for a discussion of how to determine the receiver frequency.
2. Frequency-modulate the signal with a 4.5kHz-deviated 1kHz tone.
3. Meter M1 using the IFFER and an oscilloscope.
4. Adjust L306 for a close approximation of a sine wave (as viewed on scope). This should be the first peak as L306 is advanced clockwise into the core as viewed from the foil side of the circuit board.
5. Trim L305 to slightly distort the signal viewed in step 4. This adjustment affects the multiplier stage and causes "pulling" of the crystal oscillator.
6. Reduce the signal generator's output level. Adjust L305 (multiplier), C301F (antenna), L302 (RF preamp output), L303 (RF preamp filter) and L304 (17.9MHz filter response)—in that order—to achieve maximum sensitivity.
7. Repeat step 6 as needed for maximum sensitivity. Output from signal generator should read –88.8dBm (7μV) or less for Golay and POCSAG 512. For POCSAG 1,200, the output should read –86.5dBm (10.9μV) or better. Output level is measured at the input to the 6dB attenuator at the RTL-1005 fixture.





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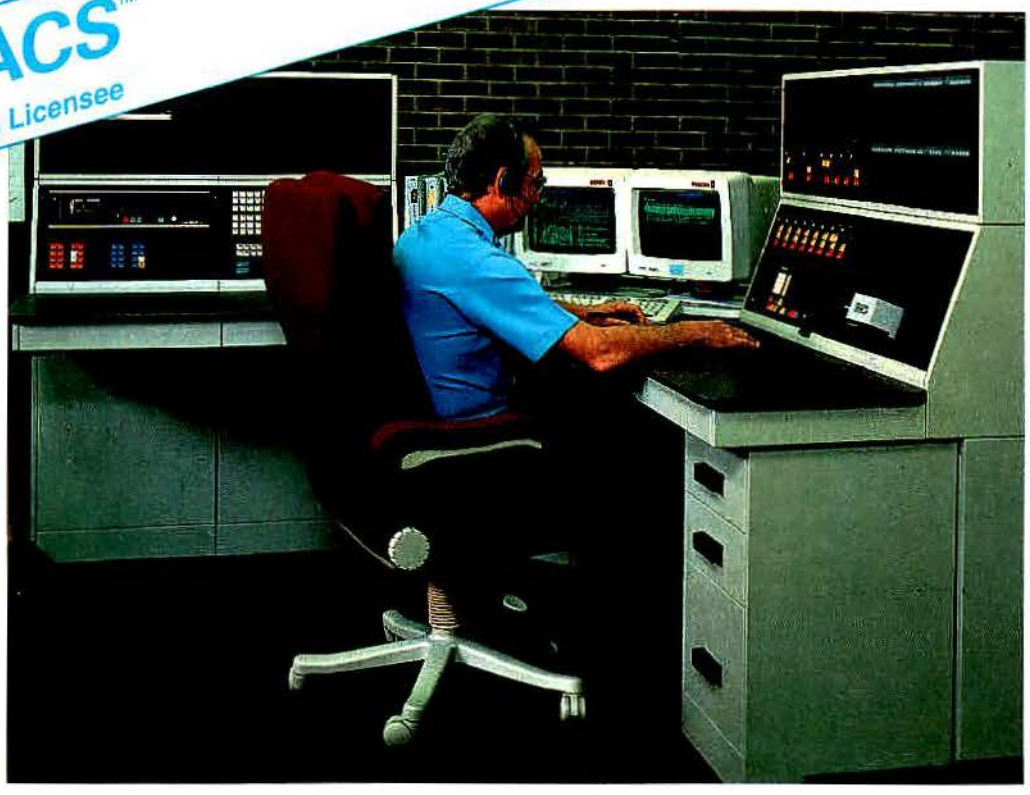

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keep the second conversion oscillator's multiple harmonics out of the bandpass of other tuned circuits, 18.355MHz is used as the second conversion oscillator frequency for some receiver frequencies.

Conversely, to keep the second conversion oscillator's multiple harmonics out of the bandpass of the same tuned circuits, 17.445MHz is used as the second conversion oscillator frequency for other receiver frequencies. A chart is included to sort them out.

Next, the first conversion oscillator multiplier stage is either a doubler or tripler, again depending on the receiver operating frequency. The 138MHz–148.599MHz receiver boards (NRD7211A,B and NRD7212A,B) use a frequency *doubler* after the first conversion oscillator. NRD7213 through NRD7217 use a frequency *tripler* after the first conversion oscillator.

A receiver board missing the identifying sticker is no big problem. After having determined that it operates in the 138MHz-174MHz range, look at the first conversion oscillator crystal. If its frequency is between 60.8MHz and 65.32MHz, the oscillator is followed by a doubler stage. If the crystal frequency is between 43.6MHz and 52.03MHz, the oscillator is followed by a tripler stage.

The second conversion oscillator crystal (the smallest crystal on the board) is supposed to be color-coded, either yellow or green. Yellow indicates a frequency of 17.445MHz and means that data inversion is *not* required. Green indicates a frequency of 18.355MHz and means that data inversion *is* required. Selecting inversion is part of the programming function (DI = Y/N under Functions).

Now that we have waded the muddied waters, let's look at the block diagram.

The antenna assembly consists of a single band of metal surrounding a ferrite bar, a variable capacitor and several fixed capacitors forming a parallel resonant circuit at the operating frequency. C303 couples the antenna signal to the *diode clamped* RF preamplifier, Q301.

A neutralizing circuit, consisting of C304 and C305, helps to stabilize the common emitter circuit. The tuned circuit formed by L302 and C306 is tuned to the operating frequency. L303 and C309 provide impedance matching to the mixer, Q302, while providing image rejection.

C310 serves as a dc isolation capacitor and has negligible bearing on the tuned circuits.

A Colpitts crystal oscillator (Q003) feeds either a tripler or doubler (depending on the board; see above) tank circuit, L305 and C317. Fine-tuning of the crystal frequency is accomplished by L306.

Mixer output at 17.9MHz is applied to the crystal filter (FL301) and routed to the *second mixer* in U001. The internal *second oscillator* operates at either 17.445MHz or 18.355MHz (see above) and mixes with the 17.9MHz first IF to develop the 455kHz second IF. Further filtering and amplification of the 455kHz signal is then FM-demodulated by the U001's *quadrature detector*.

Passed through an external RC filter (on the decoder board), the audio is converted into a data stream by peak-and-valley detectors, limited, and sent back to the decoder board for translation.

As with all the receiver boards discussed so far, this one may be turned into a full-time receiver by connecting a 10K resistor between TP10 and TP12, defeating the strobed *battery saver signal* generated by the decoder board.

Acknowledgement

I would like to thank the management and staff of JJ Sounds & Communications, South Houston, TX, for their help with this project. Tel: 713-944-1813.

'Leftovers'

The NRF series (929MHz–932MHz) pagers includes the 4017E, which has a 17.9MHz IF and a first conversion oscillator operating around 76MHz.

Use the following equation to calculate the frequency for these pagers:

$$F_{oper} = (12 \times \text{1st conv. crystal}) + 17.9\text{MHz}$$

Although I have not tried it, modifying these units to operate on other frequencies probably would be easy. Converting the first conversion oscillator into a variable crystal oscillator would require replacing the fine-tuning inductor with an external permeability-tuned inductance. Although the range of frequencies that could be tuned in this manner might be relatively small, a bank of crystals might be switched in and out of the circuit.

M1 provides a starting point for an AM detector stage, and any old LM386 will provide adequate output to feed a small speaker (when powered by a 3V–6V supply). Tap into TP6 for demodulated FM.

Here is another idea. If your facility is set up to make changing pager frequencies easy, it might be helpful to offset the first conversion oscillator to a quiet frequency before starting the alignment procedure. If the purchase of a screen room or the construction of a do-it-yourself shielded room as described in Part 1 is out of the question, shifting the frequencies of both the receiver module and the signal generator to a relatively quiet frequency would help with the alignment procedures.

In short, the Bravo receivers might just find other applications than simply beeping!

Pager servicing series

Part 1: "Build a Shielded Room," January 1994. (All pagers.)
Part 2: "Build An 'IFFER,'" February 1994. (Bravo, Bravo Plus, Bravo Express.)
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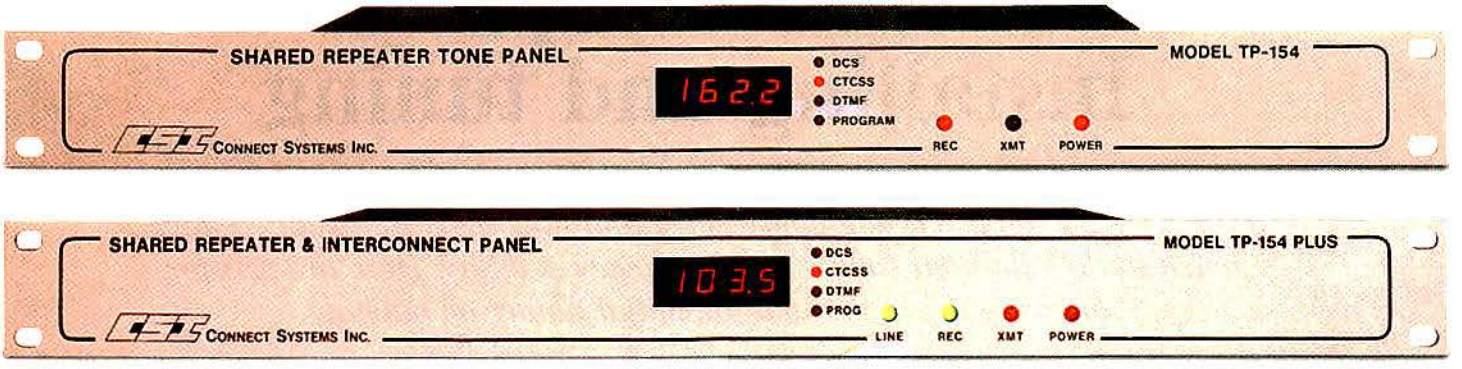

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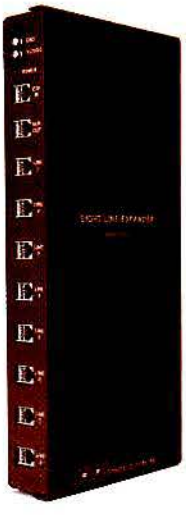

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How to use duplexers: Installing and tuning

Part 3—How duplexers are constructed and how they are installed have much to do with their tuning and frequency stability. Here are tips for ordering duplexers and for initial tuning or retuning.

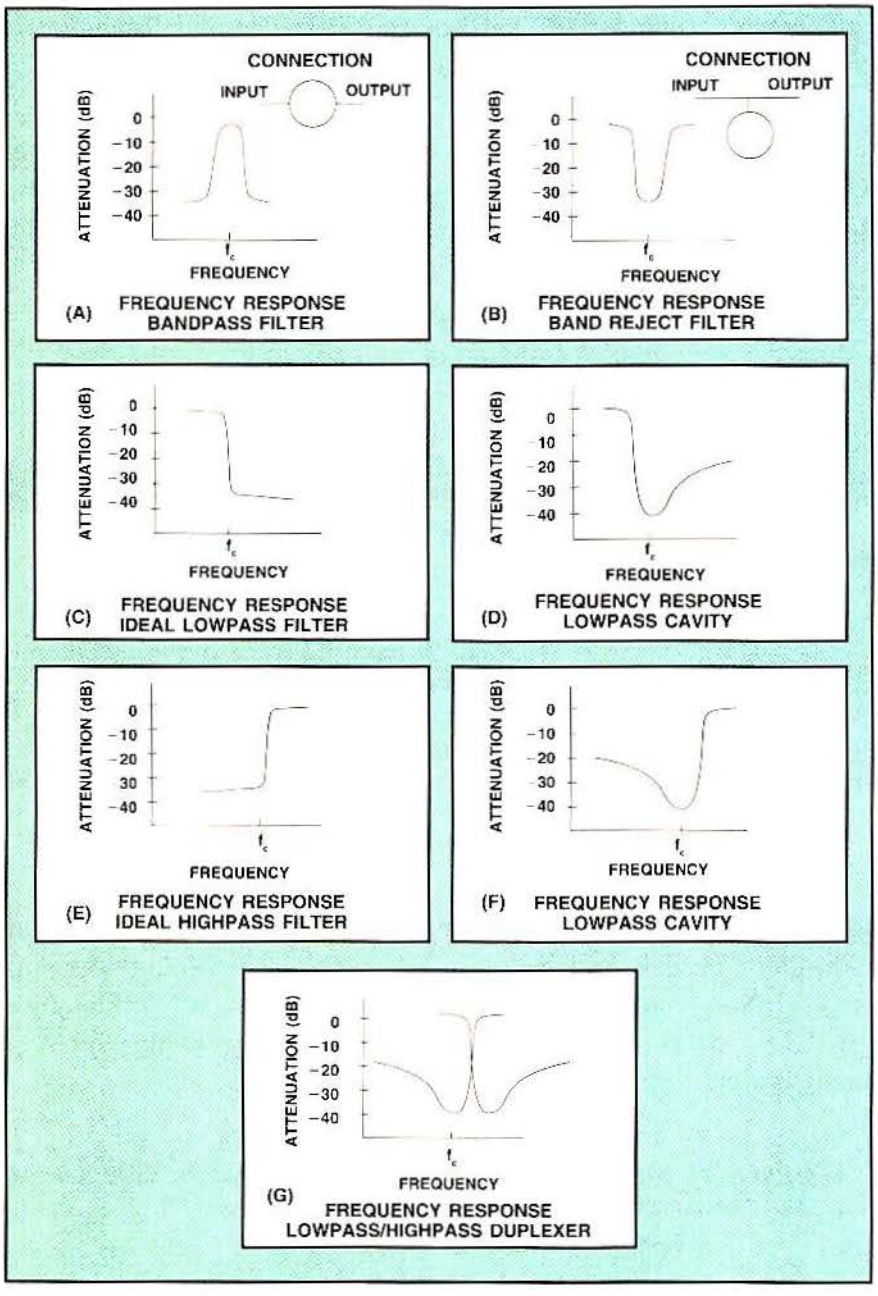

Figure 1. The easiest way to understand the use of a spectrum analyzer and tracking generator for cavity tuning is by example. Attenuation vs. frequency curves for bandpass and band-reject cavities are shown in (A) through (G) to the left.

By Brian J. Henderson, P. Eng.

Whether duplexers are used in a typical manner to support repeater operation or as filters to reduce or eliminate interference, their construction, installation and tuning affect the outcome.

Temperature

Temperature plays a big part in duplexer performance.

The volume of the cavity is extremely critical to duplexer tuning. A small temperature change can contract or expand cavity components, shifting the duplexer frequency as much as 30kHz–40kHz, enough to shut down a repeater system.

The system cannot be allowed to shut down because of a duplexer temperature problem. What do you do?

The first thing is to make sure the temperature in your repeater building remains relatively constant. Install a thermostat on an electric heater to heat a small building. Keep duplexers themselves out of drafts and away from ventilation fans and windows. Keep them out of sunlight so they are not subject to heating during the day and cooling at night.

Physical construction of duplexers

There are two methods of duplexer construction.

Henderson is senior engineer, communications, with Canadian Western Natural Gas, Calgary, Alberta.

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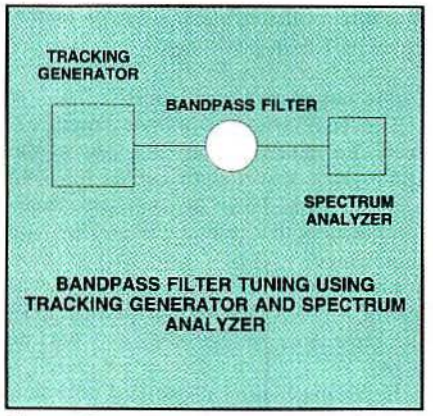


Figure 2. To replicate the example of cavity tuning described in the text, connect a tracking generator and spectrum analyzer as shown.

The older method uses round containers and associated internal components. These duplexers are more difficult to mount on equipment racks because of their shape.

Manufacturers then developed rectangular duplexers. They are compact and far more convenient for rack-mounting.

When round cavities are exposed to temperature changes, they expand equally in all directions. Tuning may or may not be affected.

When a rectangular cavity changes temperature, it expands more in one direction than another, which is certain to affect its tuning.

Generally speaking, where temperature extremes are expected, such as for unheated mountaintop locations, use a round cavity filter.

Coaxial cable

There are several factors to consider when using coaxial cable to connect cavities to make a duplexer.

(1) To preserve as much isolation as possible, always use double-shielded cable.

Use either RG-214/U or RG-400/U cable for all connections. It is a good idea to use these types of cable as jumper cables to the radio repeater and antenna connections. This keeps RF signals where they should be—inside the radio and antennas.

(2) Cable length is important.

Do not use random-length jumper cables. All cable lengths are to be either a quarter-wavelength ($^1/_4\lambda$) or a half-wavelength ($^1/_2\lambda$) to maintain the impedance presented by a cavity to the line.

(3) When calculating the cable length, take into account the cable's *velocity factor.*

When RF travels in a cable, it slows down. The difference between its velocity in free space or air and its velocity

in cable is the cable's velocity factor, expressed as a percentage.

Cable impedance and length

The coaxial cable jumper length affects the impedance at each end of the cable. Half-wavelength cables have an identical impedance at each end; quarter-wavelength cables have an opposite impedance.

For example, if the impedance at one end of a $^1/_2\lambda$ cable is high (band-reject), the impedance at the other end will be high.

If the impedance at one end of a $^1/_4\lambda$ cable is high, the impedance at the other end will be low.

Remember these rules when moving or separating cavities on an equipment rack and changing their connecting cable lengths.

For band-reject cavities, use $^1/_4\lambda$ cables. Bandpass cavities and cables between radio and filters should be $^1/_2\lambda$ long.

The spectrum analyzer

A spectrum analyzer with a tracking generator can be used for tuning duplexers.

A spectrum analyzer is similar to an oscilloscope. It displays frequency on the horizontal axis vs. amplitude on the vertical axis. Because duplexers are frequency-and-amplitude-dependent, the spectrum analyzer is ideal for tuning and aligning them.

The easiest way to understand the use of a spectrum analyzer and tracking generator is by example. Attenuation vs. frequency curves for bandpass and band-reject cavities are shown in Figure 1 on page 24.

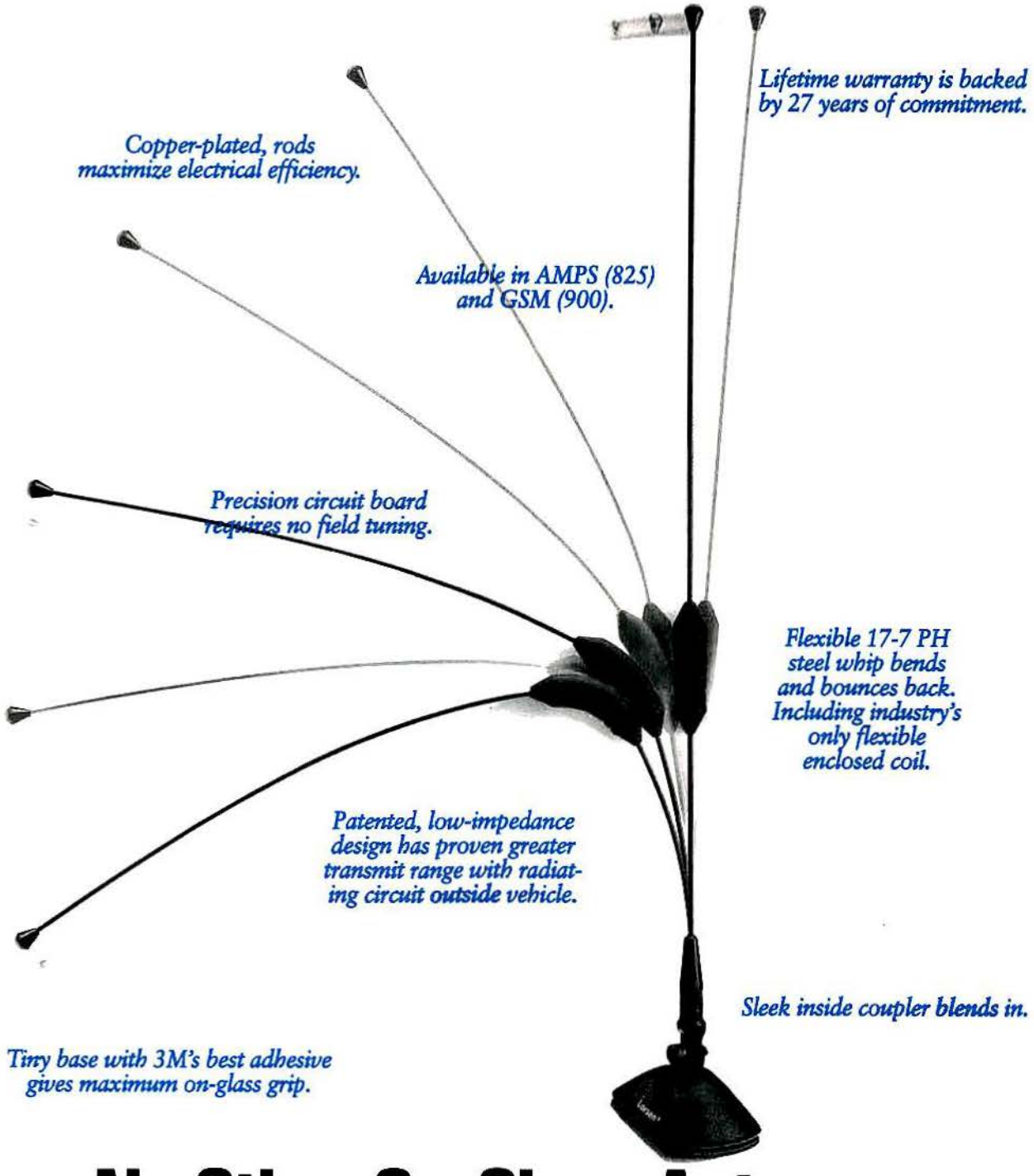
As the name implies, a bandpass cavity has low attenuation at its bandpass frequency. Other frequencies are attenuated.

Duplexer series

Previous installments in this article series include:

- "How To Use Duplexers: Isolation Requirements" in the July 1994 issue.
- "How To Use Duplexers: The Various Types" in the August 1994 issue.

Back issues printed within the past two years can be ordered for $5 each, postpaid. Call customer service at 800-441-0294. Copies of articles printed more than two years ago are unavailable from the publisher.



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The farther from the cavity's center frequency, the higher the attenuation.

A band-reject cavity is the opposite. A single frequency is rejected or "shorted out" of the circuit. Maximum attenuation occurs at the reject frequency. The further from the cavity's center frequency, the lower the attenuation.

Filter tuning

How can this information be used for tuning?

Remember the cavity configuration—*bandpass* or *band-reject*. Use the tracking generator and analyzer to produce the correct frequency curve as shown on the spectrum analyzer.

For example, consider a bandpass cavity to be tuned to a center frequency of 153.620MHz. Set the spectrum analyzer for a center display frequency of 153.620MHz. Connect the tracking generator and spectrum analyzer as shown in Figure 2 on page 27.

Loosen the locking set screws or nuts on the cavity's tuning rod. Slide the rod in or out so that the attenuation is minimized around the analyzer display's center frequency. The cavity is now tuned. Figure 1A shows the display that should appear on the analyzer.

A reject cavity produces a reverse display. Again set the spectrum analyzer center frequency to, for example, 153.620MHz. Adjust the tuning rod so that the rejection notch on the display is centered and on the correct frequency. (See Figure 1B.)

If the cavity is a band pass/band-reject type, there are two adjustments to be made. Example frequencies are 153.62MHz (pass) and 154.22MHz (reject). The bandpass adjustment is set first using the cavity tuning rod. The band-reject is set by adjusting the capacitor.

The capacitor usually is right beside the input connector on the cavity itself. It must be adjusted using either a nylon or other non-inductive tuning tool. (See Figure 1D and 1F for lowpass and highpass response curves.)

Note that most highpass/lowpass cavities can be adjusted for either highpass or lowpass configurations within certain limits by watching the analyzer display while adjusting the capacitor.

The spectrum analyzer must be used to start the tuning process, and it gets you near the correct adjustments. The analyzer will indicate whether a cavity is set for highpass or lowpass.

At the factory, fine tuning is performed with a network analyzer and return loss bridge. When such equipment is unavailable, another fine-tuning method can be used with a transmitter, wattmeter and signal generator. The filters can then be put into service with a reasonable confidence level.

Tuning rods too short?

When tuning a filter, you may find that you "run out" of tuning rod.

To go lower in frequency, the tuning rod must be pushed into the cavity. You may reach a point where the end of the rod outside the cavity is too short to push it any farther, so the cavity cannot be adjusted any lower in frequency.

When a manufacturer builds a duplexer, all the rods initially are the same length. Depending on the frequency requested when the unit originally was ordered, some tuning rods may appear longer than others after tuning.

Most manufacturers then cut the rods so that they all protrude the same distance outside the cavity. This cutting is

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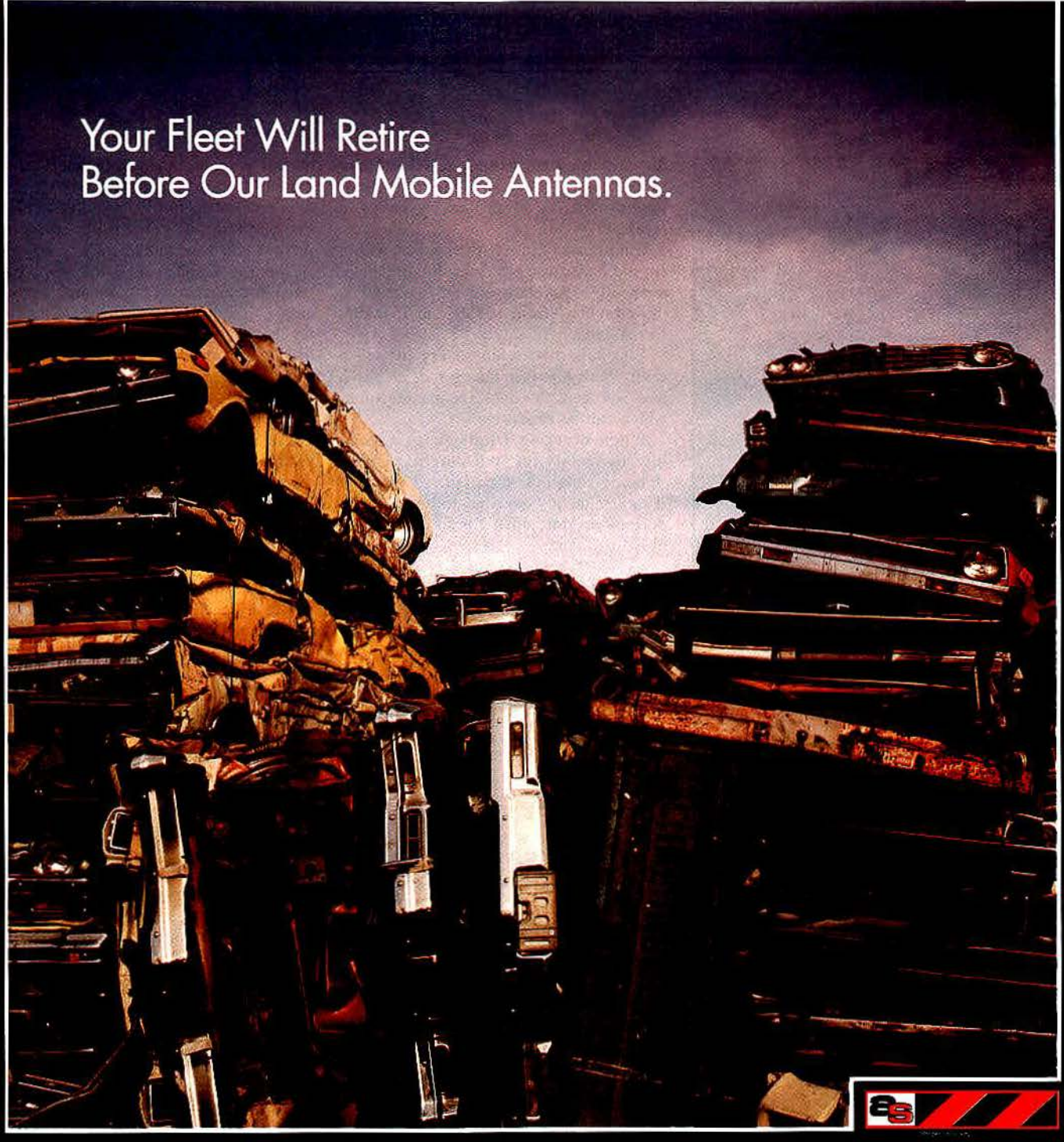

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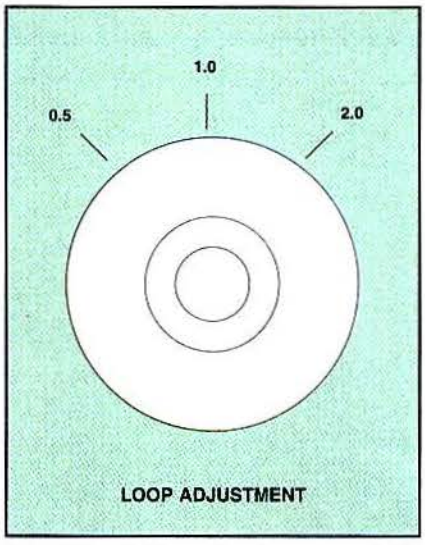

Figure 3. Inside the cavity, a loop connected to the cable connector forms the radiating and pickup element. The loop's position can change the cavity's performance. In newer cavities, the loop may be marked 0.5, 1.0 or 2.0. The loop turns when certain screws are removed. Turning the loop makes the cavity's frequency response sharper or wider as required. If an extremely selective cavity is required, rotate the loop while watching the spectrum analyzer display to narrow the cavity's bandwidth. See text for precautions.

for aesthetic reasons only. Cavities look better when their rods are an equal length—that is, if the cavity never is retuned.

Unfortunately, a cavity supplied with a cut rod may cause problems during tuning, especially when its operating frequency is moved much—from 165MHz to 151MHz, for example.

You have two options: Try to find a cavity with a longer tuning rod, or buy a new rod from the duplexer manufacturer, which can be expensive.

When ordering filters, it is a good idea to specify on your purchase order: "Tuning rods not to be cut." That way, if the frequency ever has to be changed, options are left open for further tuning or adjustment.

Tuning loops

Inside the cavity is a loop connected to the cable connector that forms the radiating and pickup element.

The loop's position can change the cavity's performance. In newer cavities, the loop may be marked 0.5, 1.0 or 2.0. The loop turns when certain screws are removed. (See Figure 3 to the left.)

Turning the loop makes the cavity's frequency response sharper or wider as required. If an extremely selective cavity is required, rotate the loop while watching the spectrum analyzer display to narrow the cavity's bandwidth.

There is a trade-off. If the loop is rotated for a narrower passband, for example, insertion loss increases. Numbers on the cavity refer to its insertion loss measured in decibels. Note that if the cavity is a bandpass type, both loops must be rotated to, for example, the 1.0dB position. Otherwise, loss will increase substantially. The cavity must remain symmetrical for proper operation.

Loop size

Tuning loops themselves are a particular length, depending on frequency.

Making a big change in frequency may require changing the loop size as determined by the manufacturer. When new loops are required, contact the manufacturer for parts and components.

Next: After initially tuning a filter using a spectrum analyzer and the technique described above, steps described in Part 4 can be used with inexpensive test equipment for fine-tuning.

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Digital signal processing in mobile radio communications

The most significant advantages derived from a DSP radio design result from placing the radio intelligence in software, which is easy to modify. The radio can be customized to operate according to particular needs.

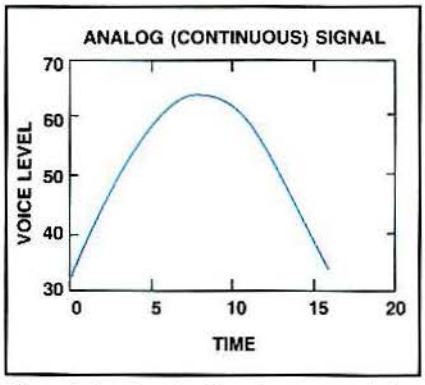

Figure 1. A voice signal can be represented as a continuous line that varies in level with time. To show how an analog voice signal becomes digital, the continuous line can be marked with 'Xs' at equal intervals (see Figure 2).

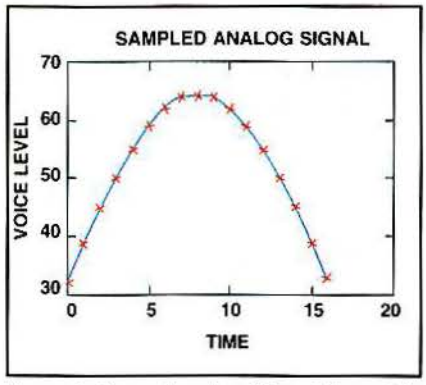

Figure 2. The voice signal from Figure 1 is marked with 'Xs' at equal intervals to represent 'sampling the signal' for conversion to digital. Typically, for voice signals, sampling occurs 8,000 times per second.

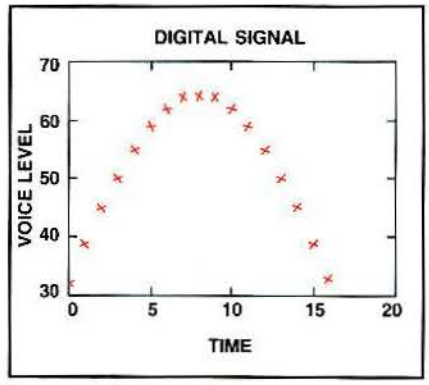

Figure 3. With the continuous line as shown in Figures 1 and 2 removed, separate points representing digital sampling are readily visible. Notice that the fourth point is at a level of about 50.

By Daniel I. Schwed

Land mobile radio (LMR) communications product users are increasingly being offered "cutting edge" technology, but is it necessary?

For instance, a salesman sees you looking at a product display and asks, "What do you think about that hi-tech *digital* hand-held radio? Its new 40 MIP digital signal processor gives you more computing power than Neil Armstrong had on the Apollo moon mission!"

You point to the slightly lower-priced model on the left. "How about that one?" you ask. The salesman says, "Oh, that's just our old analog version. It doesn't have nearly the same horsepower as our newest model."

Schwed is staff engineer, Ericsson GE Mobile Communications, Lynchburg, VA. He has designed EGE communications products for the past five years. He has a B.S.E.E. from Washington University, St. Louis. He is a member of the IEEE Signal Processing Society.

You compare the features, and you ask yourself, "What am I really getting by choosing the model with the digital signal processor? It sounds too good to pass up, but I don't want to be paying for just high-tech mumbo jumbo."

My employer was first to offer digital signal processor (DSP) technology to public service users. Digital voice was added to its enhanced digital access communication system (EDACS) trunking systems without having to replace existing equipment.

The following information focuses on the DSP technology that was incorporated into our trunking system. Engineering mathematics have been replaced by common-sense explanations.

Digital signal processing definitions

▶ *Digital* — "Digital" means "to describe as a number." Numbers are the vocabulary of computers.

Practically anything can be represented digitally. For example, a radio's volume knob might turn from 0 to 10. Zero is off. Ten is full volume. If the knob turned only in whole units, its only positions would be 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10. With the volume set to 8, instead of describing the audio as "quite loud" we could say, "It's an 8." We would be communicating in digital.

▶ *Signal* — Anything that can be sensed continually is a "signal." In LMR, the typical signal of interest is *voice* (or *speech* or *sound*). The sound of an individual speaking a word or phrase is captured by a microphone as an *analog* (continuous) signal.

Figure 1 above represents an analog voice signal as a continuous line that varies in level with time. To show how an analog voice signal becomes digital, the continuous line is marked with Xs at equal intervals. (See Figure 2 above.) This marking represents "sampling the signal." Typical voice-signal sampling occurs 8,000 times per second.

With the continuous line removed, each separate point is readily visible. (See Figure 3 above.) Notice that the fourth point is at a level of about 50.

Numbers in Figure 4 on page 36 correspond to levels marked in Figure 3. The entire number sequence represents the

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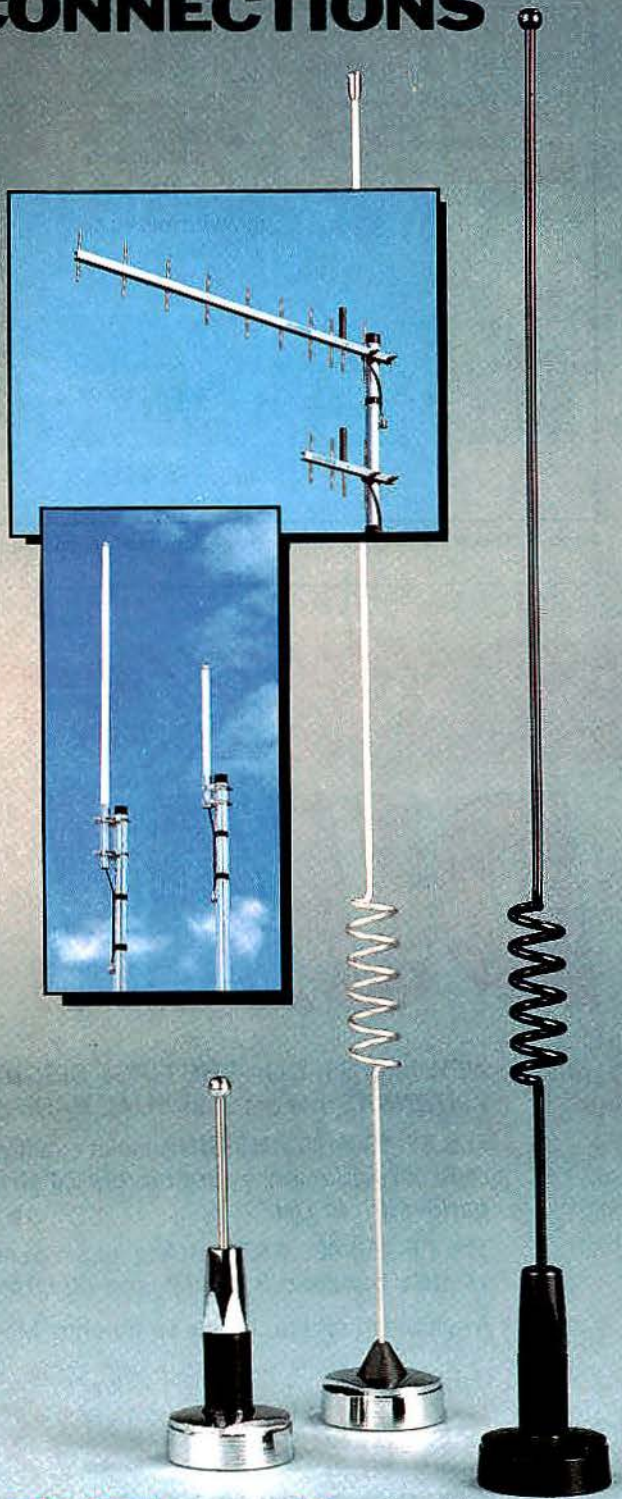

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DIGITAL =

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	32	39	45	50	55	59	62	64	64	64	62	59	55	50	45	39	33

Figure 4. These numbers correspond to levels marked in Figure 3. The entire number sequence represents the original analog voice signal shown in Figures 1 and 2.

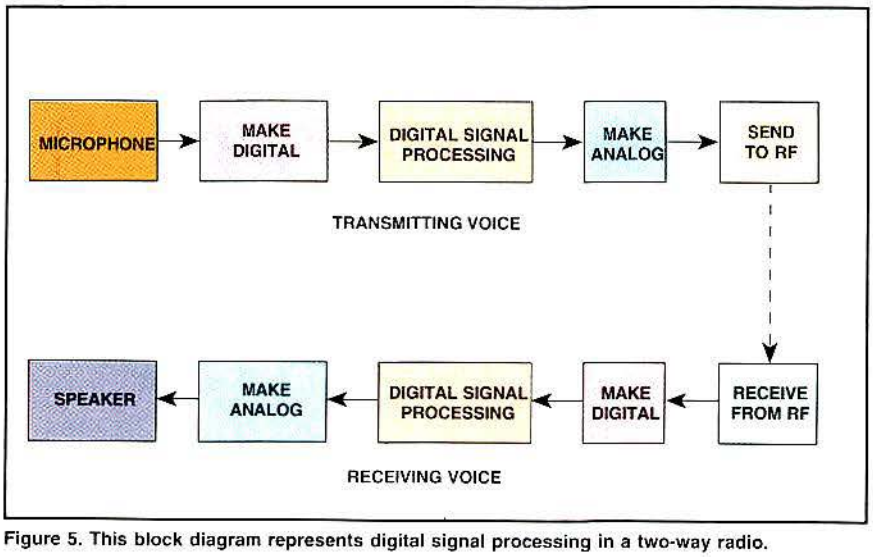


Figure 5. This block diagram represents digital signal processing in a two-way radio.

original analog voice signal.

▶ *Processing* — "Processing" describes what is done with the digital samples. A single computer chip processes the large quantity of numbers that represent a voice.

After the numbers are loaded into the DSP chip, mathematical algorithms allow the voice to be altered. Think of the voice numbers as ingredients in a recipe, the computer chip as the chef, and the computer software as the cookbook. Processing results in a "cooked," or modified, version of the voice. In LMR, voice that comes out of the DSP chip has been changed to improve transmission from sender to receiver.

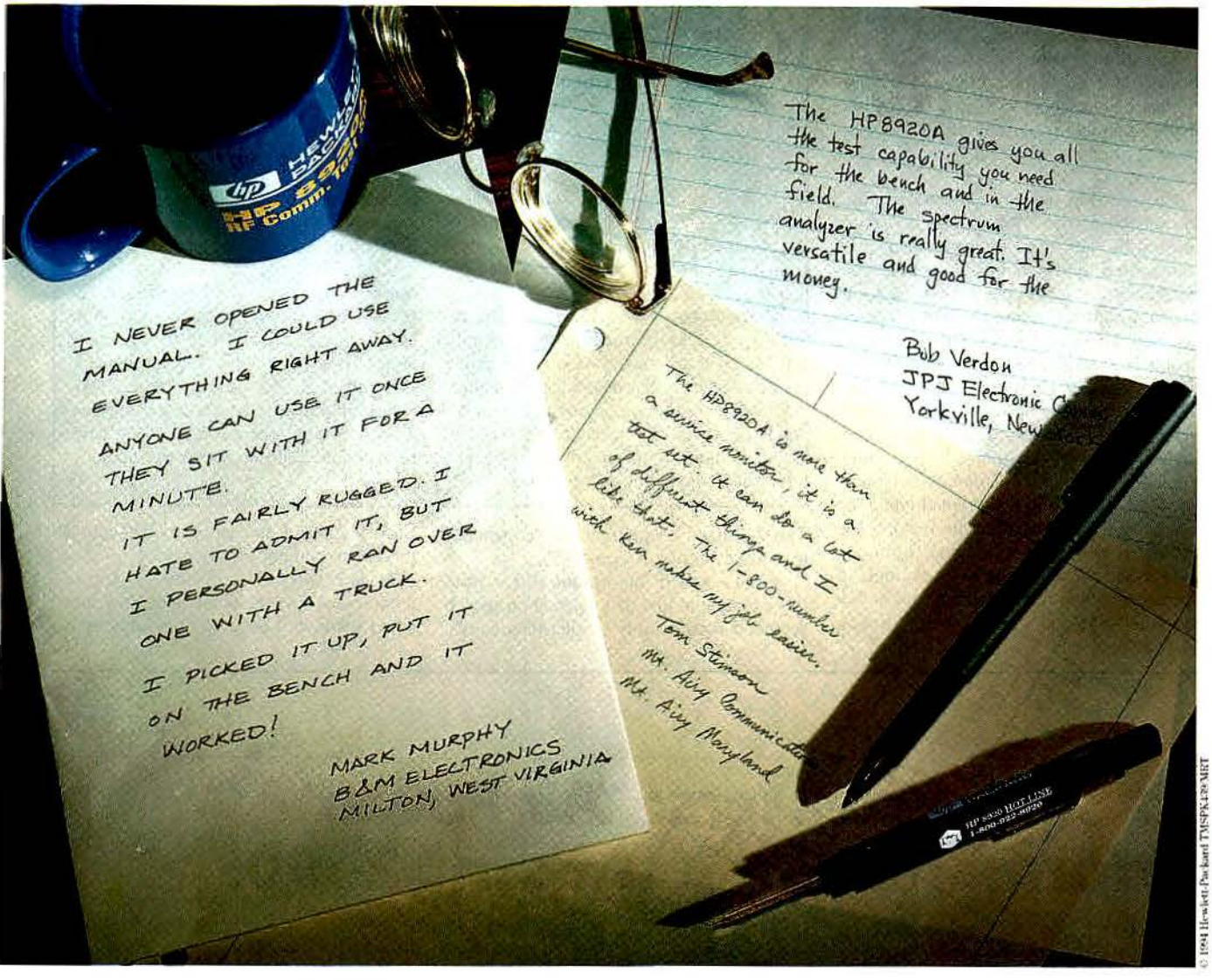
Figure 5 to the left represents digital signal processing in a radio. The processing steps in this diagram are described in the following sections.

DSP techniques

Groups of algorithms tend to use the same basic principles, or DSP techniques, to improve communications.

▶ *Speech compression and expansion*— Speech compression decreases the quantity of digital voice numbers before sending them over the radio transmitter.

"I never opened the manual for my HP 8920A."



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Expansion, the reverse of compression, is performed at the receiving radio to restore the original, larger set of speech samples to be heard on the radio speaker.

The compression and expansion processes must be compatible, so the algorithms are presented in pairs. The matching set commonly is referred to as a *vocoder*, which is short for voice coder-decoder.

Compression reduces the time required to transmit a voice. When speech is compressed by half, two conversations can be transmitted simultaneously on the same frequency, a technique known as time-division multiple-access (TDMA). The increased airwave capacity makes more channels available to reduce waiting time during hours of peak use.

How is it possible to shed part of the voice before transmitting and then restore it during reception without losing something in the process? Compression translates the speech into a shortened computer language. The receiving radio restores the translated speech to its original form.

Consider the following as an example of speech compression: A secretary takes dictation in shorthand with a few pen strokes. The shorthand notation later is "expanded" to normal text by a typist.

A radio's DSP algorithms differ from this example in that they operate on speech segments considerably smaller than words. Each second of speech is divided into 45 pieces for unique translation.

▶ *Encryption-decryption* — Digital, compressed speech sounds like stray noise when monitored on a scanner, although it

Future DSP features

□ *Battery life improvement* — The radio scales back its transmitter power when close to an RF repeater. Also, battery power is carefully monitored to indicate how much talk-time remains. Portable radios operate longer between charges.

□ *Telephone answering machine capabilities* — The radio has record and playback capabilities. Voice is saved after compression to reduce computer memory costs.

□ *Speakerphone capability* — The radio no longer requires a push-to-talk (PTT) switch. When you speak into the radio, a speech detection algorithm automatically starts transmitting. The speakerphone operates full-duplex because an echo cancellation algorithm blocks speaker audio from transmission.

□ *Voice command* — The radio no longer requires so many buttons and knobs. Using a speech recognition algorithm, it changes to the system and group that you tell it.

□ *Voice lock* — Unauthorized use of the radio is prevented because it only operates when it hears your voice, once again thanks to the speech recognition algorithm.

□ *Intelligent speaker output* — It no longer is necessary to adjust the speaker level when room noise changes. The speaker automatically adjusts for noisy and quiet environments. If room noise is recognized by the adaptive filter algorithm, antinoise is sent out the speaker along with the receive audio. (You have to experience antinoise to really appreciate it.)

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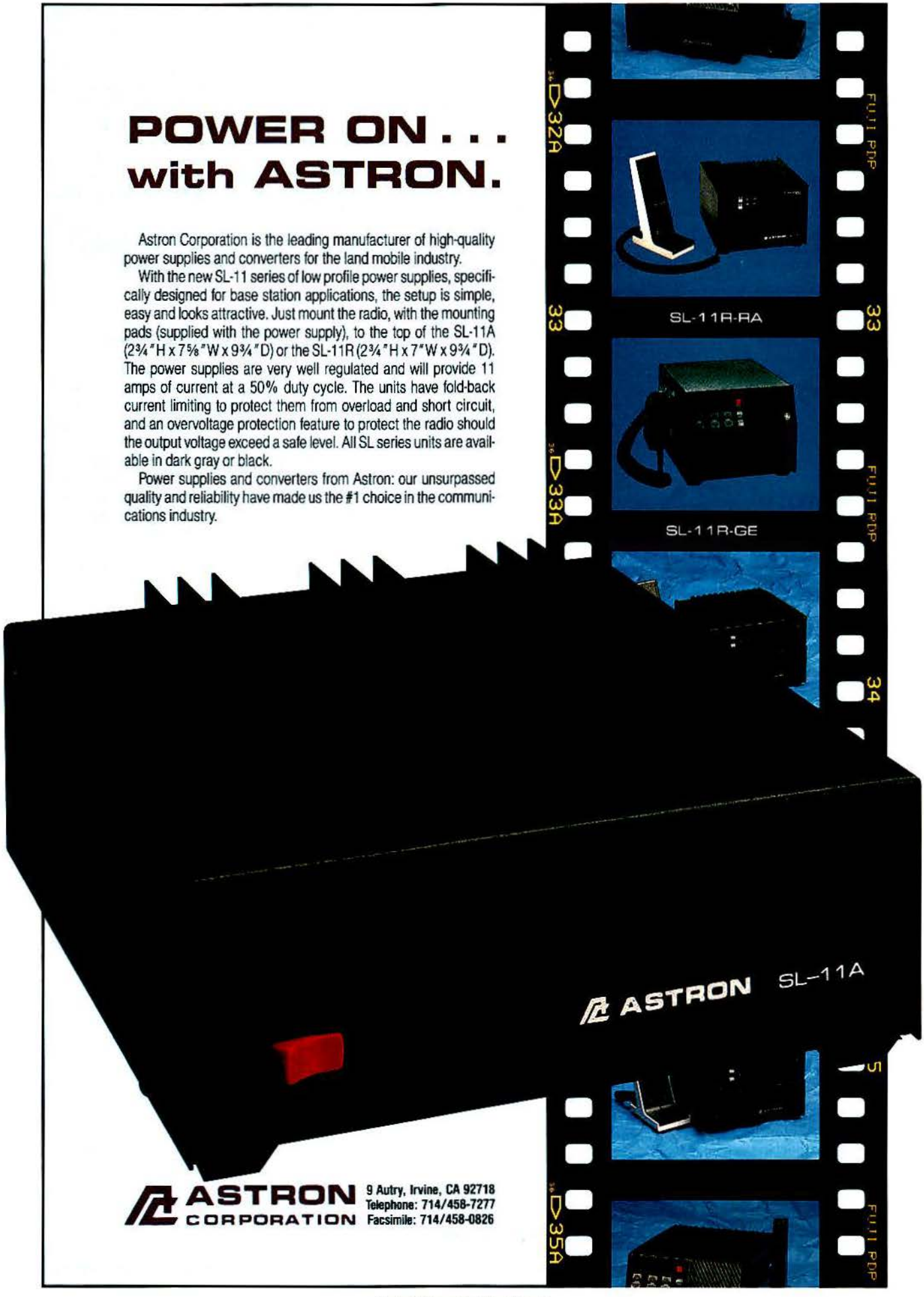

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can be heard clearly on any similar model of digital radio with the proper speech expander. Digital voice, therefore, inherently has a limited amount of security.

Encryption further secures the transmission. Speech is scrambled to sound like noise to an eavesdropper. An identical software "key" must be loaded into both the transmit and the receive radios for intelligible reception.

In an encrypted system, both transmit and receive radios create a random number for each speech number. (Random number generation is similar to flipping a coin in that the outcome, be it heads or tails, is unpredictable.) The random number and the speech number are scrambled together mathematically at the transmitter. The receive radio unscrambles the encrypted voice using an identical random number. This process requires identical random number generators in both radios.

The most essential point to make about encryption is that there are more than 1 billion billion (1 quintillion) possible keys to load into the radio. Users may change the keys whenever convenient; daily key changes usually are sufficient. Different keys may be assigned to different talk groups.

The key interacts with the random number generator to determine the order in which the random numbers are selected. Without the exact matching key, the conversation sounds like noise.

RF modulator-demodulator

The RF modulator-demodulator (modem) changes the digitized voice to improve its ability to travel cleanly through the airwaves. This optimizing function takes into account the laws of man and the laws of nature. For instance, the RF communications channel is subject to federal restrictions that specify, among other things, maximum power level and maximum channel bandwidth. In addition, the LMR environment poses physical constraints, such as "shadowing," as when the receiving radio's channel is obstructed by a building or a hill.

How does an end-user benefit from a superior-quality RF modem? First, optimizing the voice for transmission reduces the probability of digital speech errors at the receiving radio. (Error is defined as a mismatch between the digital voice number transmitted and the digital voice number received.) Fewer errors add up to increased voice quality as heard on the radio speaker.

Second, if the transmission is always good, the speech rate can be increased through a good RF modem just short of the rate at which speech errors appear. This characteristic, in technical terms, is called *improving throughput.*

Improved throughput frees transmitter airtime. When speech is transferred twice as fast as before, two conversations can be conducted on the same frequency at the same time.

Here is an example of how people take on the modem function. They instinctively modify their normal means of communication to increase effectiveness in a noisy channel.

Utility worker Bob is talking to coworker Jeff at the location of a downed power line. He *raises his voice* to be heard over the noise of a rainstorm. Their work is interrupted by a sharp *whistle* coming from about 40 feet away. They immediately turn toward the sound; they see their crew manager *pointing* to sparks coming from the next pole that has fallen down.

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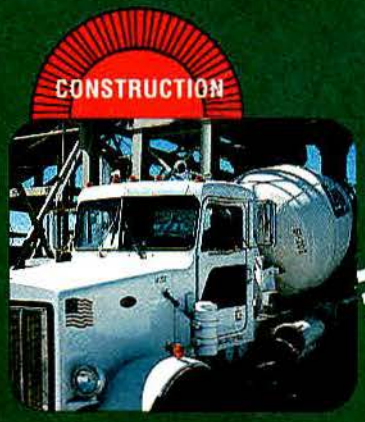

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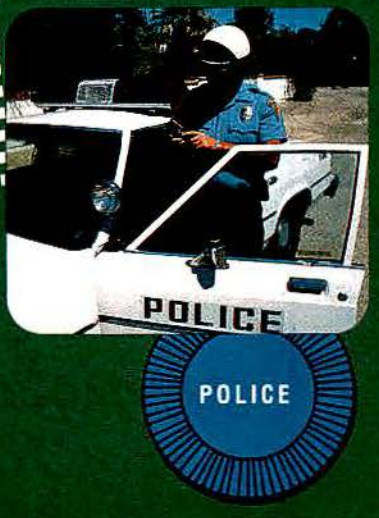

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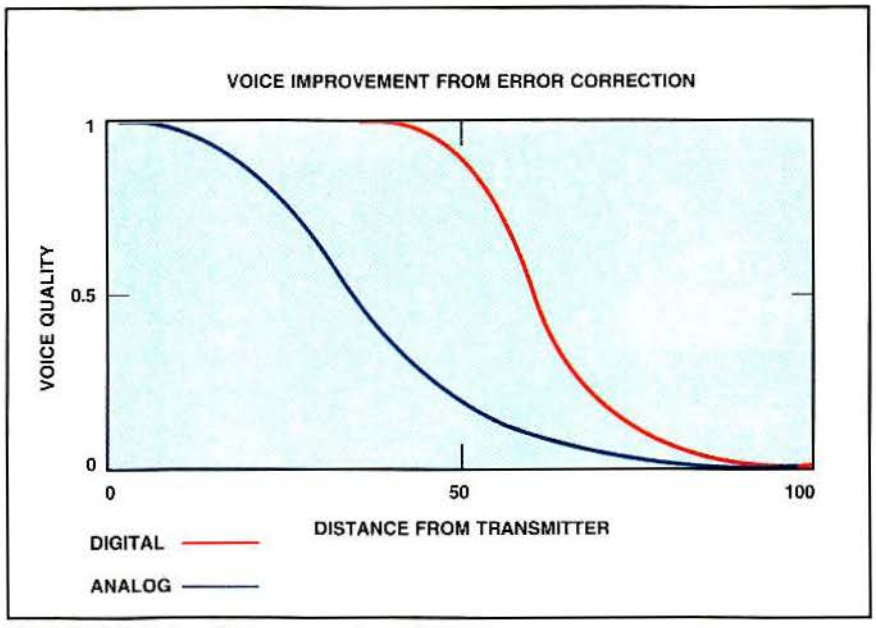


Figure 6. Digital voice with error correction typically delivers improved reception, especially as the distance between the transmitter and receiver increases, compared to analog voice. In this example, at a distance of 40, analog voice is significantly degraded, while digital voice is nearly perfect because of 100% error correction. Past 40, digital voice quality falls rapidly. The ability to correct is lost because of the large number of errors in the received signal.

improvement of the RF modem function. In addition to providing the 25kHz-to-12.5kHz channel-splitting capability (frequency-division multiple-access, or FDMA), the current technology can transmit multiple conversations through a single channel (TDMA). The combination, F-TDMA, provides a frequency migration strategy to ensure FCC compliance well into the next decade.

Error correction

In the RF modem discussion, error was defined as a mismatch between the digital voice number transmitted and the digital voice number received. Such errors reduce voice quality. Fortunately, DSP techniques allow a large number of errors to be corrected.

Error correction fixes pieces of speech that are lost or changed during transmission. A scratch in a compact disc recording goes unnoticed by a listener during playback because error correction fills the gap with the missing sound.

Similarly, radio communication error correction improves voice quality. With DSP, the effect is most noticeable at the extremities of the coverage area. Figure 6 above shows the type of improvement, compared to analog systems, typically obtained with error correction. The digital, error-corrected transmission maintains nearly perfect voice quality at a large distance from the transmitter. At a distance of 40, analog voice is significantly degraded, while digital voice is nearly perfect because of 100% error correction. Past 40, digital voice quality falls rapidly. The ability to correct is lost because of the large number of errors in the received signal.

The merits of error correction are difficult to believe at first. A user might ask, "Are you telling me that if you miss a spoken word, you can somehow get it back?" The answer is "Yes."

One class of error correction relies on redundancy. For each spoken word, three copies are transmitted. The receiving radio performs a function (called *voting*) on the received voice. Two out of three wins.

Here is an an example.

With sirens blaring, firefighter Joe is en route to a burning building downtown. Joe calls the dispatcher and engages in the following awkward conversation.

"BLEEP there any BLEEP there?"

"What?"

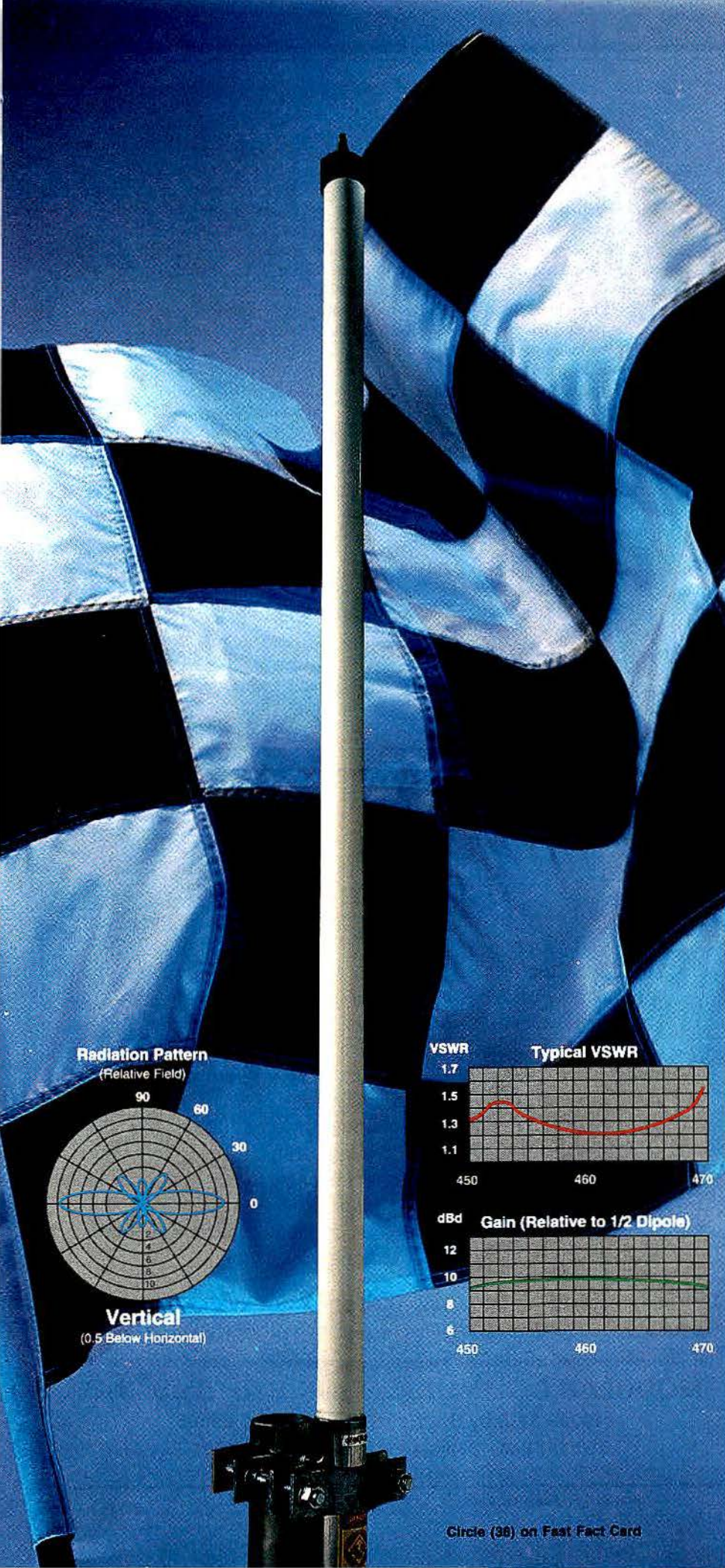
"Are there BLEEPims there?"

"What?"

"Are BLEEPny victims there?"

The dispatcher thinks about the last three interrupted messages from Joe, puts together his message and replies, "There are no victims there. The building is empty."

Another class of error correction relies upon the fact that transmitted voice can be represented by a small set of allowable numbers quite different from one another. If a number changes slightly during transmission, the receive radio can correct it. It assumes that an erroneous number should be changed to the number that it most



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resembles in the allowable set.

Here is an example of error correction using words instead of numbers:

Consider that eyes are typically described by their color.

Received Phrase	Error Corrected Phrase
The suspect has bloe eyes.	The suspect has blue eyes.
The suspect has dreen eyes.	The suspect has green eyes.
The suspect has browl eyes.	The suspect has brown eyes.

Error correction is a game of odds. It is more likely that a small number of errors will occur than a large number. If not, error correction would be useless. In this example, the receive word "dreen" may really not be "green" with one letter in error, but "brown" with three letters in error.

The error-correcting approach used in EDACS makes use of both methods described above.

Hardware replacement

Land mobile radios used to have dissimilar analog, digital and RF parts designed by analog, digital and RF electrical engineers. This "mixed" radio design approach is complex, and it requires specialists and specialized parts for what becomes a difficult radio development project.

Land mobile radios now are designed largely by digital signal processing engineers, all of whom write software for a single DSP chip. What has happened to the analog, digital and RF components? Some still exist, yet many hardware components have become unnecessary. Functions they once performed have been replaced by DSP software algorithms.

Software algorithms are flexible enough to handle multiple operating modes. For instance, F-TDMA software co-exists with software required to handle digital and analog platforms. This flexibility is the key to equipment interoperability.

Simplifying radio design by standardizing on a one-chip DSP platform offers end-user advantages. The radio can be smaller and thus easier to maneuver. In the long run, fewer parts result in lower cost and increased reliability. A radio with fewer parts is easier to build and more difficult to break.

The most significant advantages derived from a DSP radio design result from placing the radio intelligence in software. Software is easy to modify, and the radio can be customized to operate according to particular needs. It can be upgraded with next-generation software to protect it from obsolescence. The radio can operate in many modes to retain backward compatibility with older equipment. The radio usually can be examined and repaired quickly without having to take it apart. Radio feature upgrades can be obtained as needed or when they can be afforded.

When voice communication is handled digitally, it is inexpensive to add data capability. Digital data is composed of numbers that represent non-voice information. Radios can pass this information through the encryption and modem functions at no additional radio system cost.

As DSP technology matures, conventional systems will inherit features that were, at one time, only cost-effective in trunked systems.

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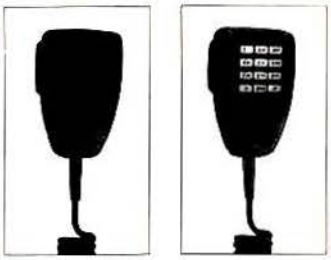

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(continued from page 8)

A transparency of Figure 1 can be made to fit the scale of a topographic map and can be used as an overlay to determine the elevation of the various points required for calculating average terrain elevation. The tower site or center point is used eight times in the calculations, once for each radial, so it carries more weight than the other points on the radials. Once the elevation at each of the points is determined, they are added together. Then the sum is divided by 48 to yield the *average terrain elevation.*

Once the average terrain elevation is determined, the HAAT, or effective antenna height, is determined by adding the antenna tower height above ground level (AGL) to the tower site elevation above sea level (ASL), then subtracting the average terrain elevation. The step-by-step process is shown in the table on page 48.

Effective mobile antenna height

For mobile antennas, a factor known as *minimum effective height* must be considered. The graph in Figure 2 on page 8 provides an approximation of the minimum effective mobile antenna height over *poor soil, good soil* and *sea water.* The dashed lines indicate that the minimum effective height of a mobile antenna at 150MHz is approximately 6 feet. The minimum effective height should be used for calculations if it is greater than the *actual* height of the mobile antenna. If the actual height of the mobile antenna is greater than the minimum effective height, then the actual height should be used.

Antenna gain figures

When using various formulas involving propagation and path loss, the *reference antenna* for the antenna gain figures must be clearly understood. A lossless halfwave dipole has a gain of 2.15dB over the isotropic radiator (a theoretical antenna with equal radiation in all directions). When the isotropic radiator is used as the reference, the gain should be stated in *dBi.* When the halfwave dipole is used as the reference, the gain should be stated in *dBd.*

Mobile antennas usually are referenced to the quarterwave mobile antenna. Compared to a halfwave dipole, the quarterwave mobile antenna would have a gain of about −1dBd.

Effective radiated power

The term effective radiated power (ERP) takes into consideration any losses or gains in the system between the transmitter output and the antenna (including antenna gain). It is easier to work with dBm or dBW units of measure because line losses and antenna gains are usually given in dB. To convert transmitter output to dBW, use the following formula:

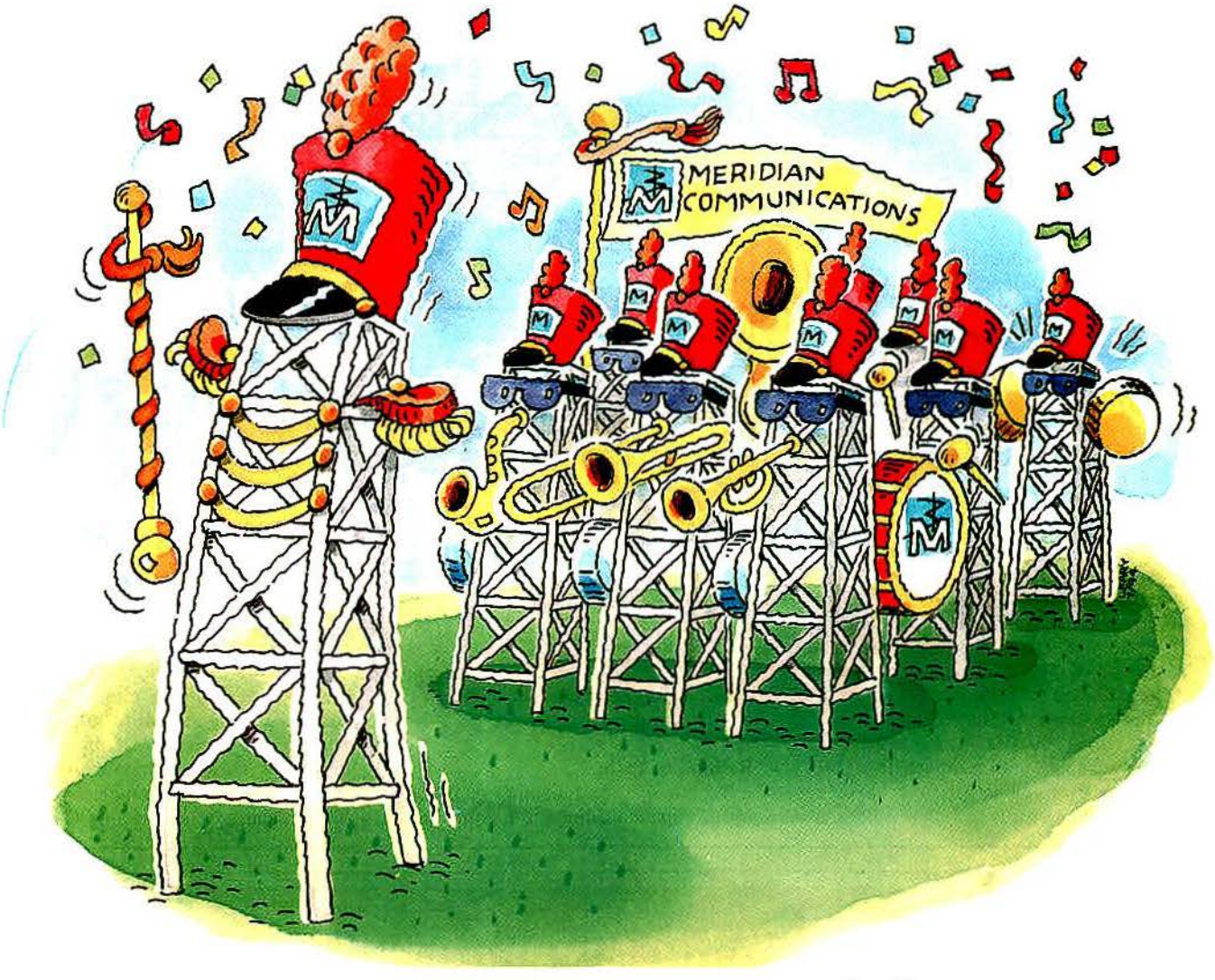
$$dBW = 10\log P \qquad [1]$$

To convert dBW back to power in watts use this formula:

$$\text{watts} = \text{antilog}\,(dBW/10) \qquad [2]$$

As an example, suppose that a transmitter has an output of 100W, a transmission line loss of 2dB and an antenna gain of 5dBd. The transmitter output in dBW is:

$$\begin{aligned} dBW &= 10\log(100) \\ &= 10(2) \\ &= 20dBW \end{aligned}$$



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The effective radiated power is:

20dBW − 2dB + 5dB = 23dBW

The ERP in watts is found from:

watts = antilog(dBW/10)
= antilog(23/10)
= antilog(2.3)
= 199.5W

Noise degradation

If the mobile unit is operating in a heavily industrialized area, the noise level probably will cause significant degradation of the signal. That is, a higher signal level will be required to produce a given level of quieting or a given SINAD ratio from the receiver. The noise problem is less severe at VHF highband than on VHF lowband. As the operating frequency increases, the noise problem decreases.

According to *Electronic Communications Handbook* (1988 McGraw-Hill), the noise degradation in suburban residential New York is 10dB at 150MHz, 6dB at 450MHz and 0dB at 900MHz. In rural areas, the noise degradation would be much less: 2dB or 3dB or even less in extremely quiet areas. One noise factor is the ignition noise coming from the vehicle itself. This is one noise source that the mobile receiver cannot avoid. It can greatly degrade reception even at VHF highband frequencies.

RADIAL AZIMUTH	DISTANCE FROM TOWER IN MILES					
	0	2	4	6	8	10
0°	690	600	650	625	670	700
45°	690	570	590	615	650	625
90°	690	600	615	690	710	640
135°	690	625	640	675	700	680
180°	690	700	750	725	730	740
225°	690	680	680	690	640	650
270°	690	710	700	690	725	740
315°	690	710	740	750	710	700
TOTALS	5,520 (A)	5,195 (B)	5,365 (C)	5,460 (D)	5,535 (E)	5,475 (F)

(1) Add column totals (A) through (F) = 32,550
(2) Average terrain = step (1) ÷ 48 = 678.125
(3) Tower site elevation = 690
(4) Antenna height = 500
(5) HAAT = (3) + (4) − (2) = 511.875

Table 1. Step-by-step process for determining height above average terrain.

Reliability ratio

To improve the reliability or probability of communications, a fade margin or reliability margin must be built into any formula for calculating radio coverage area or range. Higher probability factors require greater reliability ratios or fade margins in decibels. In the following graphs of radio communications range, the probability of communication is 90%. The reliability ratios are: 14dB for VHF

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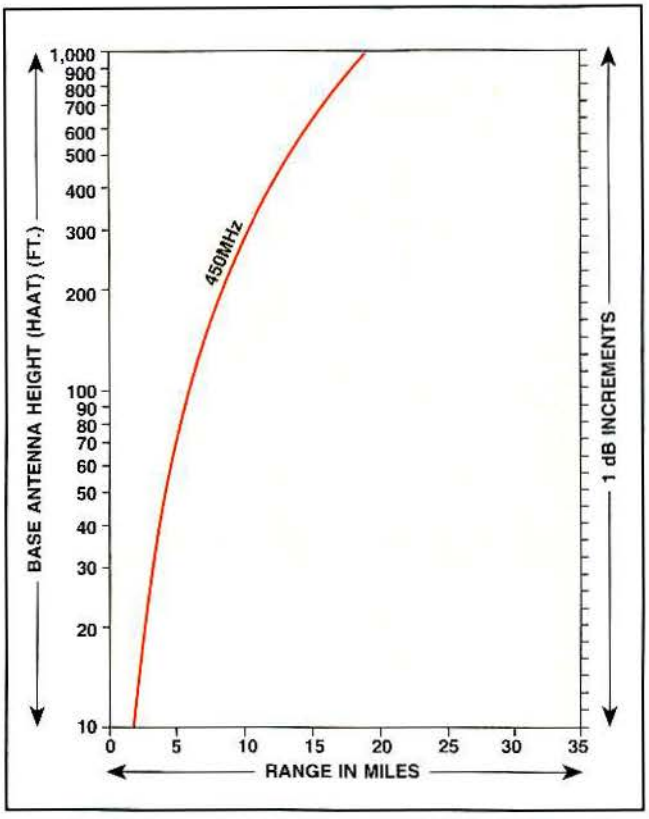

Figure 4. This is a graph of range vs. tower height for 450MHz with an effective radiated power (ERP) of 100W. The complete set of operating characteristics is: ERP = 100W; gain of mobile antenna = −1dBd; receiver line loss = 1.5dB; noise degradation = 1dB; receiver antenna height = 6 feet; probability of communication = 90%.

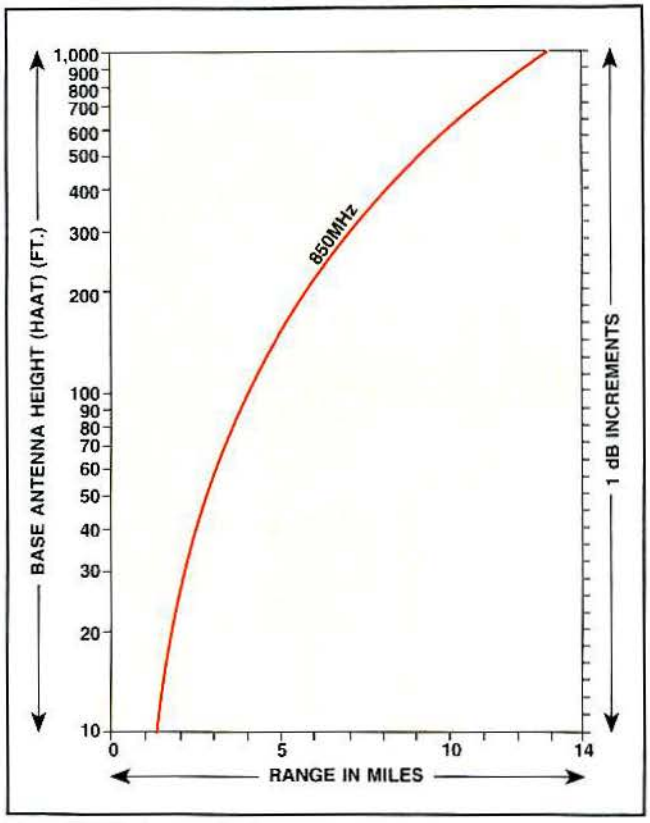

Figure 5. This is a graph of range vs. tower height for 850MHz with an effective radiated power (ERP) of 100W. The complete set of operating characteristics is: ERP = 100W; gain of mobile antenna = −1dBd; receiver line loss = 1.5dB; noise degradation = 0dB; receiver antenna height = 6 feet; probability of communication = 90%.

highband, 17dB for UHF and 19dB for 850MHz.

Radio coverage graphs

The graphs of radio range are based on terrain data from the Eastern Seaboard and Central Plains states with gently rolling terrain and average hill heights of 50 feet.

Three graphs are presented: Figure 3 on page 8 for VHF highband (155MHz), Figure 4 above left for UHF (450MHz) and Figure 5 above right for 800MHz (850MHz). Because all of these graphs are similar, only one will be described here. The graph in Figure 3 is for VHF highband. The various characteristics are listed. If the characteristics you need to use differ from those listed for this graph, adjustments can be made using the vertical decibel scale at the right. For example, this graph is based on an effective radiated power

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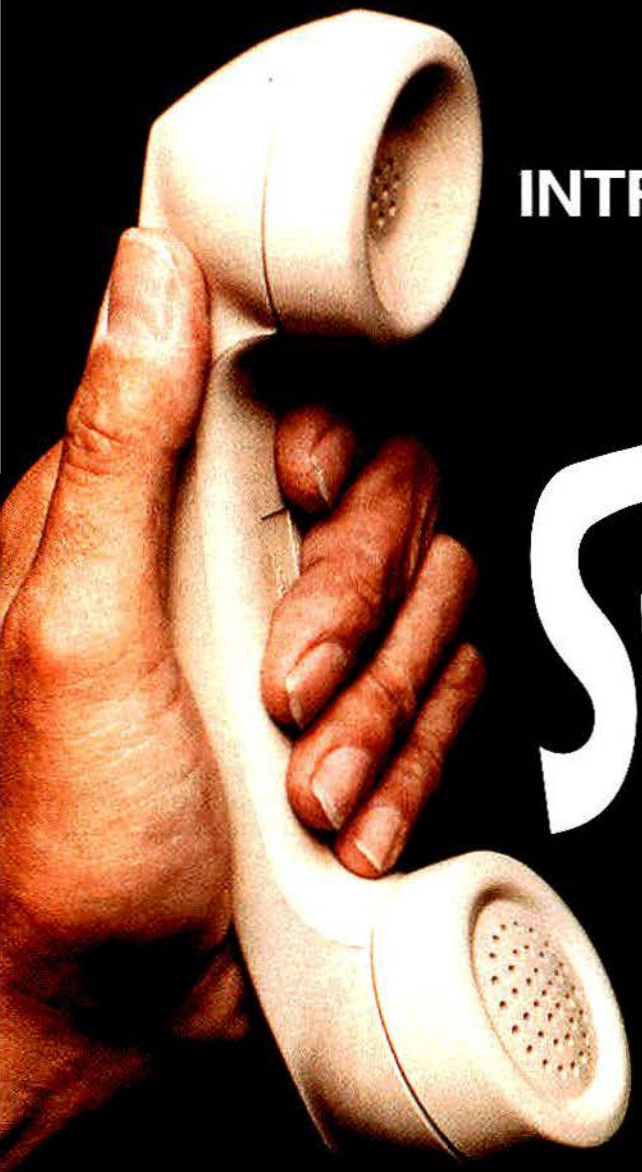

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(ERP) of 100W. If the ERP you are using is different, simply apply the formula:

$$dB = 10\log(P/100) \quad [3]$$

where

P = effective radiated power in watts.

This calculation yields a dB correction figure to apply to the graph. For example, if the ERP is 200W, a +3dB correction figure results from Formula 3. Here is how to apply the correction figure to the graph.

Suppose, in Figure 3, that the antenna height (HAAT) is 200 feet. According to the graph, the range for 100W ERP is approximately 15.3 miles. If the effective radiated power is 200W instead of 100W, the dB correction figure will be +3dB. To get the range for 200W ERP, move from the 200-foot point over to the right dB scale and up 3dB. Move back over to the graph and down to the horizontal range scale to find the new range of approximately 18.3 miles for the corrected ERP figure.

Corrections for different noise levels also can be applied the same way. Receiver sensitivity also can be adjusted this way. For example, the graph in Figure 3 is for a receiver sensitivity of 0.35V (12dB SINAD). If your receiver sensitivity is 0.7V, the correction factor would be:

$$\begin{aligned} dB &= 20\log(0.35/S) \\ &= 20\log(0.35/0.7) \\ &= 20\log(0.5) \\ &= 20(-0.3) \\ &= -6dB \end{aligned}$$

where

S = 12dB SINAD sensitivity in V.

Be sure to observe the value signs of the dB correction factors. Negative correction factors reduce the range, and positive correction factors increase the range.

Figure 3 shows that doubling the antenna height is equivalent to a 6dB change. This relationship means that the same effect can be achieved by using a higher-gain base antenna, using a higher-gain mobile antenna, using better transmission line to reduce line losses, increasing transmitter power, using receivers with better sensitivity or any combination of the above that results in a net increase of 6dB.

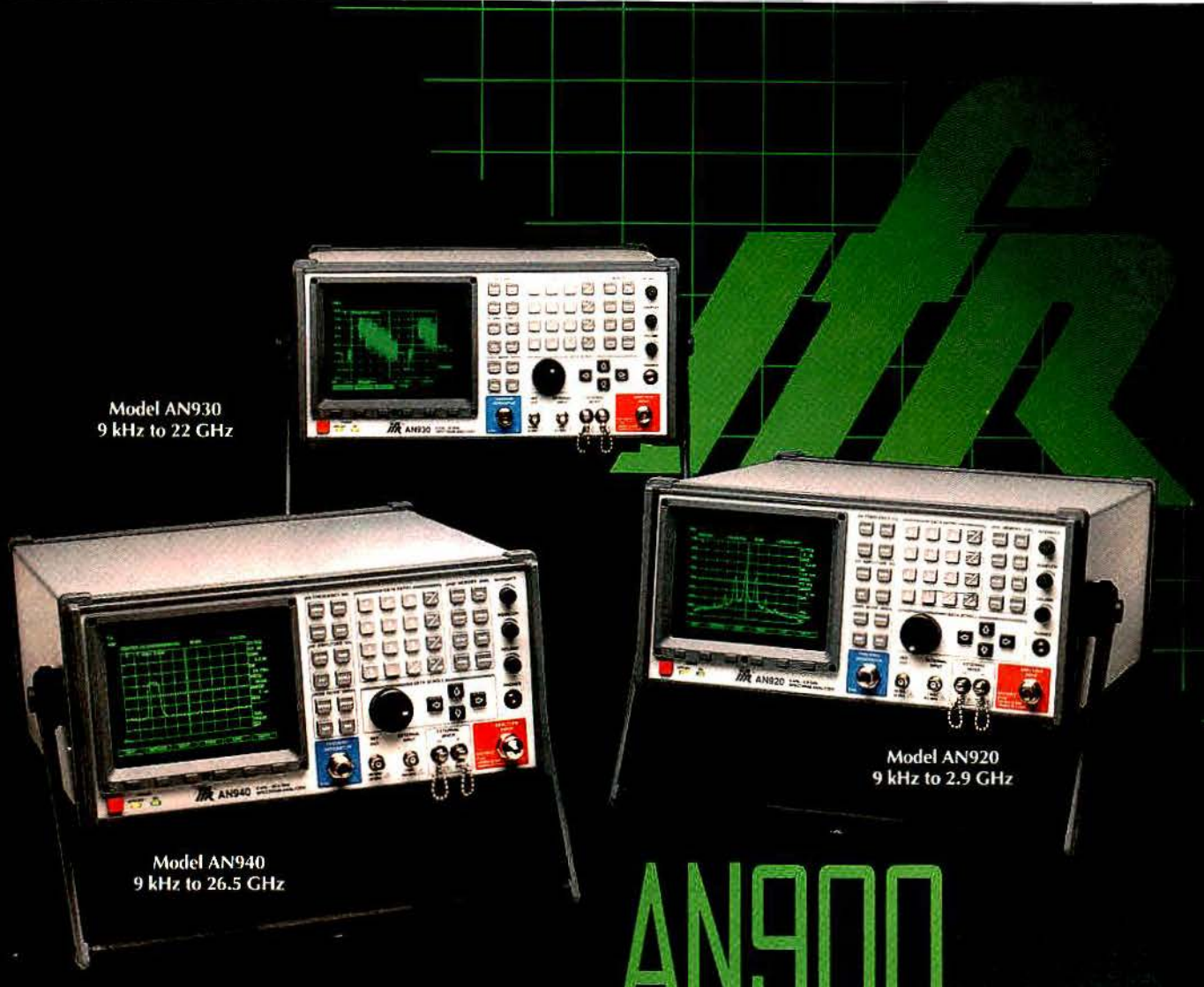
Figure 3 also shows that a 6dB increase boosts the range by about 40%. A 12dB increase extends the range by about 100%. For example, to increase the range by 40%, we could increase the antenna gain of the base station by 3dB and double the power (another 3dB increase).

Quadrupling the antenna height is equivalent to a 12dB change. This change is equal to increasing the transmitter power by a factor of 16. The increase in antenna height must be effective height or HAAT. For example, if the average terrain elevation is 750 feet, the antenna tower is 200 feet and the tower site elevation is 1,500 feet, then the HAAT is 1,500' + 200' − 750' = 950'. If the actual tower height is doubled (from 200 feet to 400 feet) the new effective height is: 1,500' + 400' − 750' = 1,150'. Thus, the *effective* height increased from 950 feet to 1,150 feet, much less than double. This change would result in only a slight improvement.

The graphs in Figures 4 and 5 are similar to the graph in Figure 3, but they are for 450MHz and 850MHz operations. Graphs such as these must be used cautiously and with two parts common sense! Even so, they are useful in making a determination of average coverages to be expected from given operating characteristics.

Computerized coverage plots

Computerized coverage plots have taken



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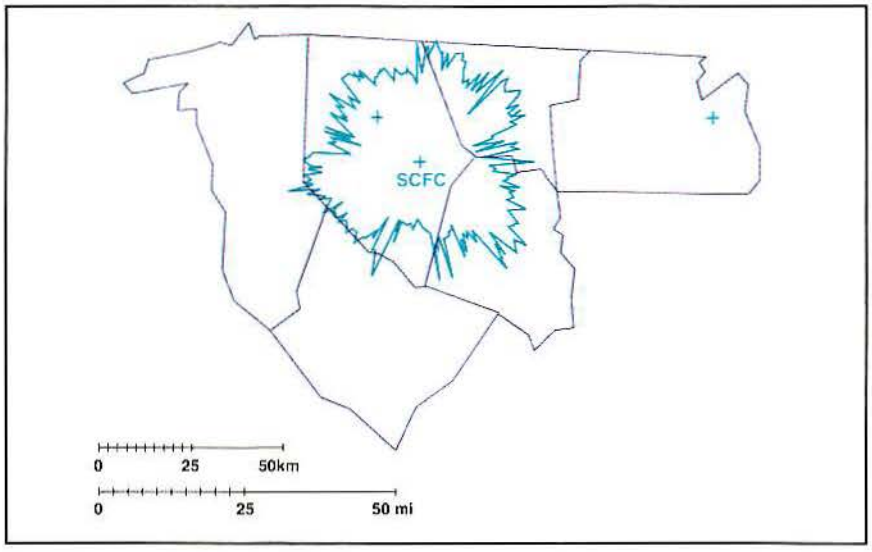

Figure 6. This radio coverage plot was produced with SoftWright's Terrain Analysis Package. The various terrain elevations are retrieved from a terrain database and the various elevations are computed for each point (at 0.1-mile increments) on each radial. This plot contained 360 radials. This contour is for 16dBu or 6.3μV/m. Considering a mobile antenna gain of −1dBd and a line loss of 1.5dB, this will produce slightly more than 1μV at the receiver input at 160MHz along the 16dBu contour.

much of the guesswork out of radio range calculation. Computer programs take into account effective radiated power, required signal level, probability of communications, terrain elevations, antenna height and other pertinent factors. Coverage plots can be printed on a dot matrix printer or a plotter with county-line boundaries included on the plot.

Figure 6 at the left shows a computer-generated contour plot prepared with SoftWright's Terrain Analysis Package software. This plot was prepared using 360 radials at 1° spacing. The incremental value on each radial was 0.1 mile. This plot provided a contour with excellent resolution. The signal level for this contour was 16dBu. At 160MHz, with a line loss of 1.5dB and a quarterwave mobile antenna, the signal level at the receiver input is slightly higher than 1μV.

Several computer programs that are useful in determining signal level, radio range, path loss, HAAT calculations and ERP calculations are available from the author. The cost is $10 plus $2.50 for shipping and handling. Please specify 3½-inch or 5¼-inch floppy disk. These programs are for IBM-compatible PCs running MS-DOS. Write to the author at 204 Tanglewylde Drive, Spartanburg, SC 29301-2949.

Stay tuned!

References

1. *VHF and UHF Propagation*, Datafile Bulletin 10003-1, General Electric, Lynchburg, VA, 1962.

2. Inglis, Andrew F., *Electronic Communications Handbook*, McGraw-Hill, New York, 1988.

3. Singer, Edward, *Land Mobile Radio Systems*, Prentice-Hall, Englewood Cliffs, NJ, 1989.

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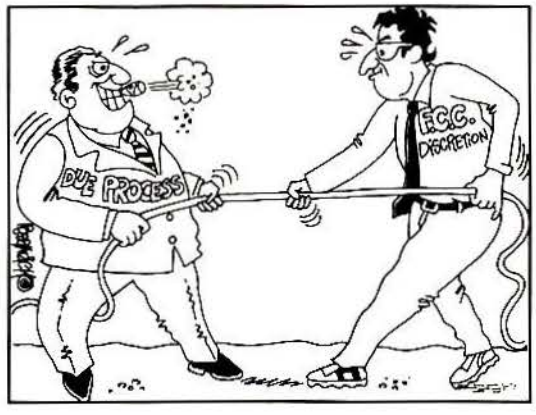
MOTOROLA

Dateline: Washington, DC, July 4, 1994

By Robert H. Schwaninger Jr.

It's Independence Day. A time for fireworks, backyard barbecues, parades and waving the flag. We are celebrating the birth of this great country as we do every year. Marine bands will march and bottle rockets will fill the night. In towns across the country, potato salad, chicken and watermelon will be consumed in grand and glorious quantities as family and friends gather to celebrate one enduring concept: freedom.



Amid the clatter of plates and the boom of pyrotechnic marvels, there is, unfortunately, another sound. The sound of an FCC official demanding again and again and again that a California specialized mobile radio (SMR) system operator turn over all of his records, permits, end-user information, frequency information, National Forest Service permits and any other document that pleases the government official. The operator has thus far refused, citing the FCC's lack of jurisdiction and justification for the demands. The FCC official has responded to the operator's defense by stating, in effect, "You have no right to refuse."

There it is—a stalemate. The operator believes that he is being made a victim of his competitors' use of the regulatory agency as a weapon against him. The FCC official believes that the operator has something to hide. Who is right? You decide.

According to letters sent by W. Riley Hollingsworth, deputy chief of the FCC Private Radio Bureau's Licensing Division, the FCC's demand arises out of complaints, by person or persons unknown, that James Kay, the SMR operator, is not operating his facilities in accord with the FCC rules. Kay has requested that copies of the complaints be made available to him so that he might respond to the specific charges contained within them. Hollingsworth has refused to turn over the complaints, stating that the FCC has an

Schwaninger, *MRT's* regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC. He is a member of the Radio Club of America. The firm of Brown and Schwaninger is representing James Kay in the FCC actions described in this column.

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obligation to maintain the confidentiality of the complaining parties. Kay has responded by stating that he does not require the identity of the complaining parties. Rather, he wants to review the content of the complaints. Hollingsworth has repeatedly refused this request.

Where the parties are on this July Fourth is at an impasse. Hollingsworth has stated that Kay must turn over the information or be subjected to a hearing to determine whether he possesses the requisite "character qualifications" to be a commission licensee. Kay asserts that without the content of the complaints, he is unable to defend his interests against unreasonable search of his records. Until this matter is resolved, Hollingsworth has ordered that all of Kay's pending applications remain that way, deferring further action on any.

There are other facts that make this case extremely interesting. First, within the last 20 months, Kay has provided customer information to the FCC on request on two occasions prior to this most recent inquiry. Each time Kay cooperated with the FCC's request, and each time he was not cited for any violation of the FCC rules. Kay's ire is, therefore, due in part to the FCC's asking for similar information for a third time in a relatively short period.

Second, copies of the agency's letter inquiry to Kay were sent by the FCC staff to at least six people outside the agency without Kay's knowledge. The FCC has not yet revealed the identity of the six people; however, Kay believes that his competitors must have been on the FCC's mailing list, because soon after his receipt of the official inquiry, a copy of the letter inquiry was being used by Kay's competitors to encourage his customers to leave his system. Why the FCC chose to distribute this information has not been revealed by the FCC staff.

Third, a close reading of the Communications Act and the FCC rules makes it clear that if Kay were to turn over lists of customer names to the FCC, his competitors could gain access to such lists through the use of the Freedom of Information Act. Given the FCC's earlier assistance to Kay's competitors via the distribution of the letter inquiry, Kay's fears regarding whether his customer information will be held in strict confidence, have been greatly increased. Kay's confidence in the commission took a further jolt when the FCC requested 50 copies of the demanded information.

Finally, the FCC has now promised to attempt to hold in confidence (if it can) Kay's proprietary customer information. Originally, the FCC stated, in effect, "Send us the information, and then we will decide whether it is worthy of confidential treatment." One can easily imagine the risk involved in first sending the information and then waiting to see if the FCC were going to distribute it to the public.

Perhaps the most disturbing aspect of this matter is the attitude being shown by the FCC's correspondence. The commission is telling Kay that he is not entitled to review the complaints and that he is not entitled to defend himself against the agency's sweeping inquiry into his business. It appears that the constitutional guarantees of "due process of law" and "the right of the people to be secure in their persons, houses, papers, and effects against unreasonable searches and seizures" are being thrown over for a new concept: Administrative Efficiency and Regulatory Discretion.

Under the law, Kay is entitled to respectfully decline to answer unreasonable requests. For example, if the FCC requested information which is wholly irrelevant to the operation of radio facilities

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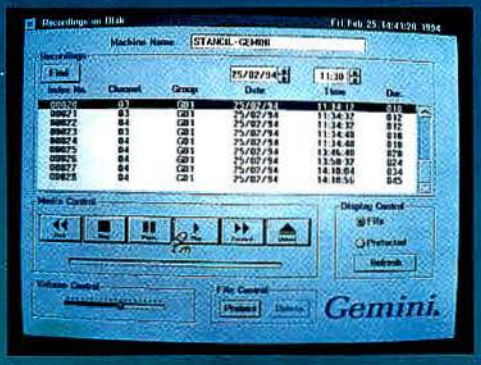

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Regulating technology

(e.g., "Did you vote for Ross Perot?") an operator obviously would not lose his license for refusing to answer. But the Kay matter is somewhat murkier.

The FCC is stating that it can require customer information again and again. Hollingsworth is demanding copies of National Forest Service permits, although the FCC has no jurisdiction over this matter and the information is fully available from another federal agency. The FCC staff wants a list of Kay's licenses, despite the fact that the information is in the commission's files. And, through it all, the FCC is stating that Kay is not entitled to defend himself from this intrusion into his business records. In fact, by deferring action on his pending applications, the FCC has shown that it is willing to punish Kay for asserting his legal rights.

So why doesn't James Kay just give Hollingsworth what he wants? Kay claims that it is both a matter of principle and an attempt to maintain the confidentiality of his customer list from his competitors' prying eyes. Hollingsworth claims that the FCC is surprised and chagrined at Kay's refusal thus far, including Kay's lawsuit before the U.S. District Court under the Freedom of Information Act to obtain the contents of the complaints.

Kay is an aggressive and litigious competitor in the marketplace. His reputation is one of intelligence, toughness, thoroughness and "take no prisoners" in his competitive stance. Kay has made enemies who would revel in the demise of his business. In fact, Kay's business enemies must be celebrating his fight with the FCC over the pending inquiry.

Does Kay's rough-and-tumble style exempt him from protection under the law? I don't think so. Sitting here on Independence Day, I contemplate the protections that Americans have to be secure in their persons and property. I cannot find any exemption to that principle, whether the threat to that security comes from a sheriff, a police officer or an FCC official. It is also difficult to imagine that the laws do not protect battle-hardened businessmen.

What if Kay turned over all of the demanded information? If the information demonstrates that there was no basis for the complaints and that Kay is operating in strict accord with the FCC rules, as was found on the two previous occasions, what remedy does Kay have against the complaining parties? None. Meanwhile, his competitors would have access to a comprehensive list of Kay's customers, including contact names and telephone numbers.

It seems to this befuddled writer that there must be a difference between patriot and patsy. One should be able to seek protection under the law without having one's character called into question. What greater test of character is there than doing what you think is morally and legally right, even when threatened with ruin? Perhaps the FCC should be asking itself a single question: "Is the public interest served by this exercise, or are officials merely expressing their anger at being challenged to justify their actions?" The answer might solve the entire problem.

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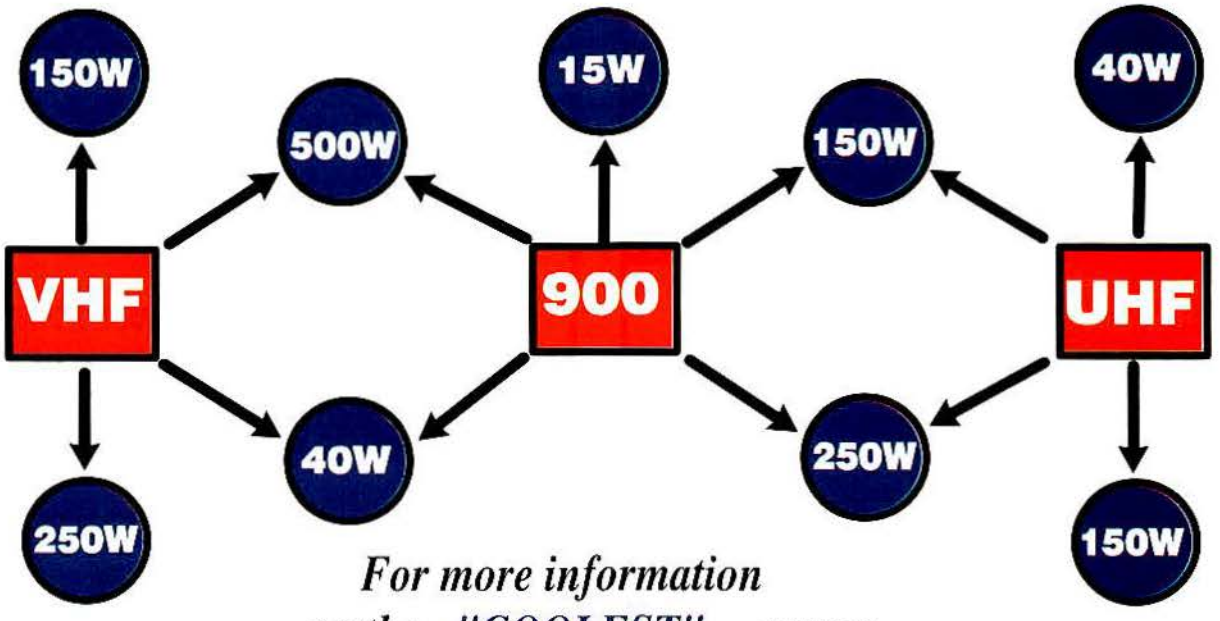

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IEEE seeks papers for vehicular technology conference

The Institute of Electrical and Electronics Engineers (IEEE) Vehicular Technology Society and the Chicago section of the IEEE are seeking technical papers for the 45th annual international vehicular technology conference, "Count-down to the Wireless 21st Century," to be held July 26-28, 1995 in Chicago.

Examples of topics are digital radio and cellular technology, PCS trial experiences, wireless data services and systems, mobile satellite systems, in-building wireless systems, modulation coding and multiple access, automotive electronics, railroad/mass transit controls, intelligent vehicle highway systems and RF propagation and antenna technology.

The due dates for abstracts and papers are as follows: Abstracts, Oct. 1, 1994; full papers, Nov. 1, 1994; acceptances will be mailed on Dec. 15, 1994; and camera-ready copy is due on March 15, 1995.

ElectroCom installs county-wide mobile data communications system

ElectroCom Communication Systems, Santa Fe Springs, CA, has been contracted by the Sangamon County, IL, Sheriff's Department to provide a countywide mobile data communications system. Ninety-two MDT-870 mobile data terminals, which are capable of accommodating automatic vehicle location devices, and Ericsson GE MDX mobile radios will be installed.

The system is designed to handle as many as 300 active mobile units at any time and will give authorized law enforcement agencies in Sangamon County direct access to state and national crime information databases.

The MDCS network control processor, the RDC-101 radio data controller from ElectroCom, provides an interface with the department's existing computer-aided dispatch system. The dispatch system will relay messages from the mobile terminals to the appropriate destinations without dispatcher intervention.

Washington State Patrol expands mobile computer project

The Washington State Patrol's pilot mobile computer project has been expanded to a six-year implementation of a statewide system. The expansion comes after the pilot project won an award from the International Association of Chiefs of Police citing it as a "unique, innovative, cost-effective network communications software for the patrol vehicle."

Dataradio, Atlanta, is providing all mobile radio modems and datalinking equipment for the system. The network will use Challenger mobile radios from E.F. Johnson, Burnsville, MN, and the Trooper model mobile computer terminal from Edge Systems.

AAT Communications acquires sites

ATT Communications, Edison, NJ, has acquired three site networks in Augusta, GA, Indianapolis, IN, and Montgomery, AL, which are all configured for multi-user applications. The three networks include 20 towers.

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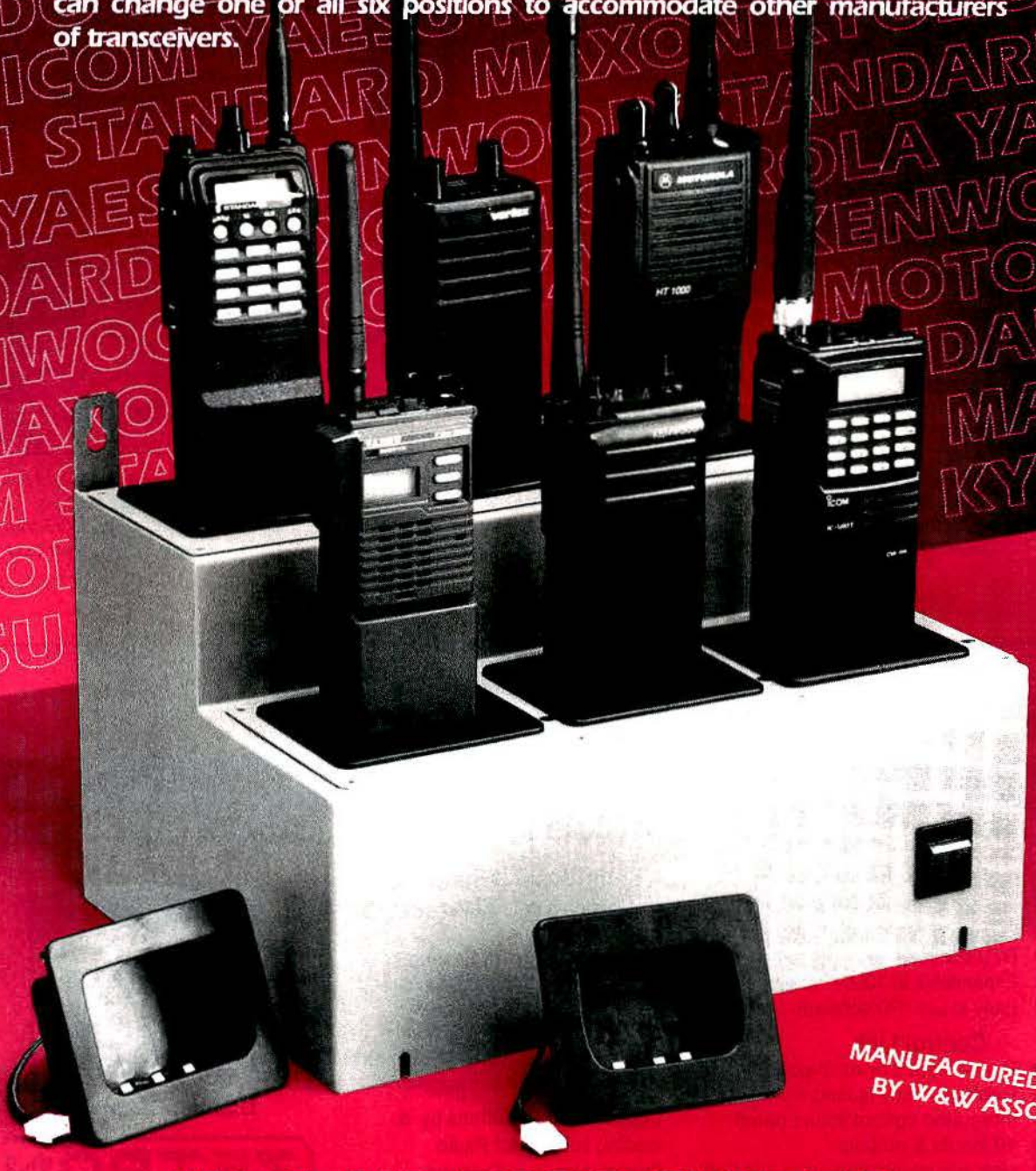

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Readers' choice

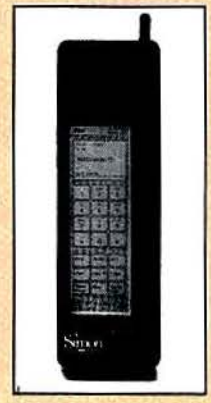
Of all the new products and services in the February 1994 issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them. Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

Cable-connection seal installs without heat shrinking or tapes

Celwave's Great Seal for cable connections is a cold shrink seal designed to withstand hostile environments, aging and exposure. The rubber sleeves of the seal are dilated and mounted on a removable plastic core. The seal is installed by slipping it over a cable connection and pulling out the plastic support coil. The seal compresses instantly, even in subfreezing weather, into a tight, form-fitting barrier that stops water migration.

Circle (501) on Fast Fact Card

Personal communicator combines cellular phone, fax, pager & E-mail

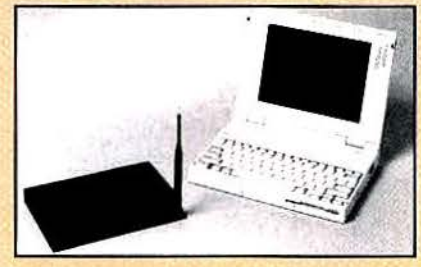


Simon is a fully integrated, handheld cellular phone, wireless fax, pager, E-mail terminal, calendar, appointment scheduler, address book, calculator and pen-based note pad/sketch pad. The 18-ounce personal communicator was designed by IBM and is distributed exclusively in the United States by **BellSouth Cellular**. The back-lit LCD functions both as a keypad and as a touchscreen. Simon's PCMCIA card slot allows user to add a paging card to receive alphanumeric pages and electronic messages on a national, regional or local basis through **MobileComm**, BellSouth's paging company.

MobileComm is the exclusive service provider for Simon wireless messaging. The PCMCIA messaging receiver is manufactured by **Motorola.**

Circle (500) on Fast Fact Card

Comm system provides mobile access to CDPD, cellular voice and fax



The Ubiquity 2000 is a cellular digital packet data (CDPD) communications system for use with IBM-compatible mobile computers. The NiCd battery-powered cellular system from **Pacific Communication Sciences** provides access to CDPD circuit-switched cellular data, cellular voice, cellular fax, wireline data, wireline fax and wireline voice. Users can attach a handset or headset to the unit to make telephone calls, dialing from the keyboard or from programs that automatically dial with modem commands. Accessories include an attachment holster, serial connection cable and an ac adapter. The Ubiquity 2000 is Windows and MS-DOS-compatible.

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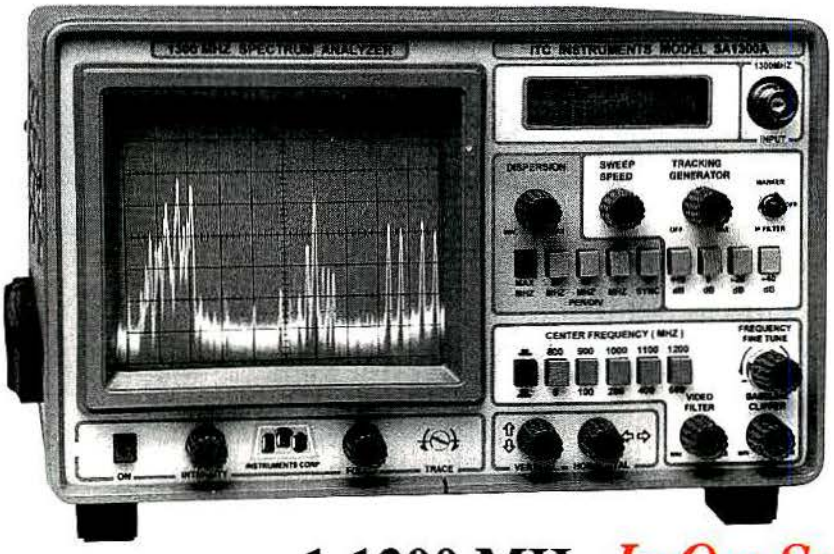

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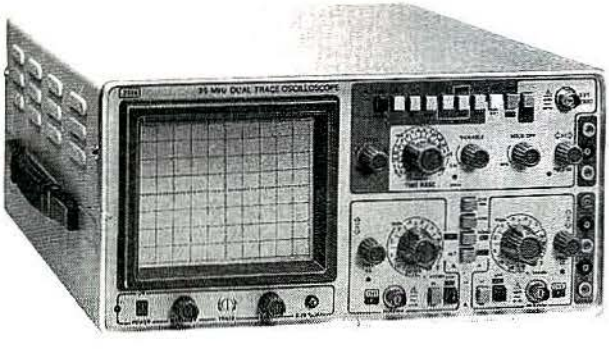

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Hand-held, wide-range receiver memorizes 1,000 channel locations

The Trident TR-1200 wide-range, hand-held receiver from **Ace Communications** receives voice broadcast frequencies from 500kHz to 1.3GHz. Its demodulation modes are: AM for broadcast and world-band, and for civil and military aviation; narrowband FM for police, fire and emergency transmissions; and wide-band FM for radio and TV audio broadcasts. Desired frequencies are entered on the front keypad, and entries are displayed on a backlit LCD. The unit searches for active channels and allows the user to store as many as 1,000 locations in permanent memory. Ten search ranges can be set and entered into memory by the user. The 5⅞"H × 2"W × 1½"D unit comes with a built-in speaker, an earphone, a dc adapter plug, an ac battery charger, a belt clip and a flexible antenna.

Circle (350) on Fast Fact Card

Log periodic directional antennas have aluminum booms, secure welds

The MLPDA-1508 and MLPDA-45010 VHF and UHF series log periodic directional antennas from **Maxrad** are broadbanded in frequency range (42MHz in VHF, 80MHz in UHF). The antennas have small sidelobes, and the boom is constructed of 6061-T6 aluminum. Elements are secured with complete 360° welds.

Circle (351) on Fast Fact Card

Nickel-plated 50Ω coax connectors conform to multiple 7/16 standards

The 7/16" series coaxial connectors from **Delta Electronics** conform to DIN 47223 and other applicable IEC, VG and CECC standards. The 50Ω connectors have an M 29 × 1.5 mating thread and a VSWR as low as 1.07:1 at 2GHz, depending on cable type. The connectors are nickel-plated brass with Teflon insulators.

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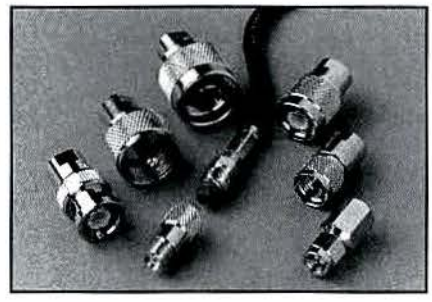

Larsen Electronics' HyPer Connect System is a universal master connector for all major radio brands. The system offers an alternative to installing and stocking a wide variety of connector types by preinstalling a universal connector on the coax. The system also provides a wide variety of adapter connectors, including PL, N, TNC, BNC, Mini-UHF and SMA. The combined loss is only 0.1dB.

Circle (353) on Fast Fact Card

Surge protector incorporates quarterwave shorting stub into connector

Andrew's Arrestor Plus one-piece connector-surge protector shields personnel and equipment from current induced by lightning strikes. The design incorporates a quarterwave shorting stub into a connector body that attaches directly to Andrew's ½" coaxial cable. The arrestor is available for field attachment or as a prefabricated custom jumper assembly. A variety of interfaces are available, including type N-male, type N-female, 7/16" DIN-male and 7/16" DIN-female.

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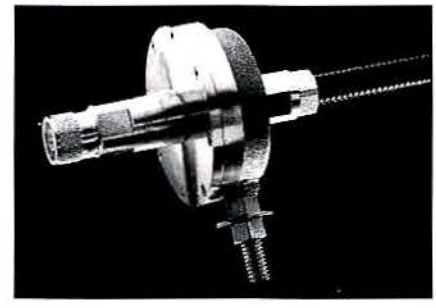

Linear amplifier allows fault ID while monitoring HF SSB activities

SGC's SmartPowerCube linear amplifier is a microprocessor-controlled unit that boosts power 500W. The unit's front panel status LEDs function as built-in test equipment (BITE) to allow quick fault identification by the operator. The unit constantly monitors HF SSB activities, power needs and antenna conditions and can select the right broadband filter in less than 15ms. The amplifier is protected from preprogrammed shutdown procedures, but it shuts down automatically in the event of a microprocessor fault.

Circle (355) on Fast Fact Card

Antenna for 30MHz–88MHz mates lowband and broadband features

The EXW lowband, broadband antenna from **Centurion International** covers 30MHz–88MHz. The antenna is designed to couple the durability and performance of a lowband antenna with the added features of a broadband antenna.

Circle (356) on Fast Fact Card

Baud-programmable pager features improved battery life, time stamp

The Facts Replay baud-programmable numeric pager from **NEC America** allows carriers to use highband and UHF units on 512-baud and 1,200-baud systems, or 900MHz units on 512-, 1,200- and 2,400-baud systems. The pager stores eight messages as long as 20 digits and has one-button access to the menu and features. The Replay's battery life is nearly double that of previous NEC pagers, providing 1,600–2,150 hours on one AA battery. Other features include a clock and time stamp, selectable alert options, and a detachable belt clip.

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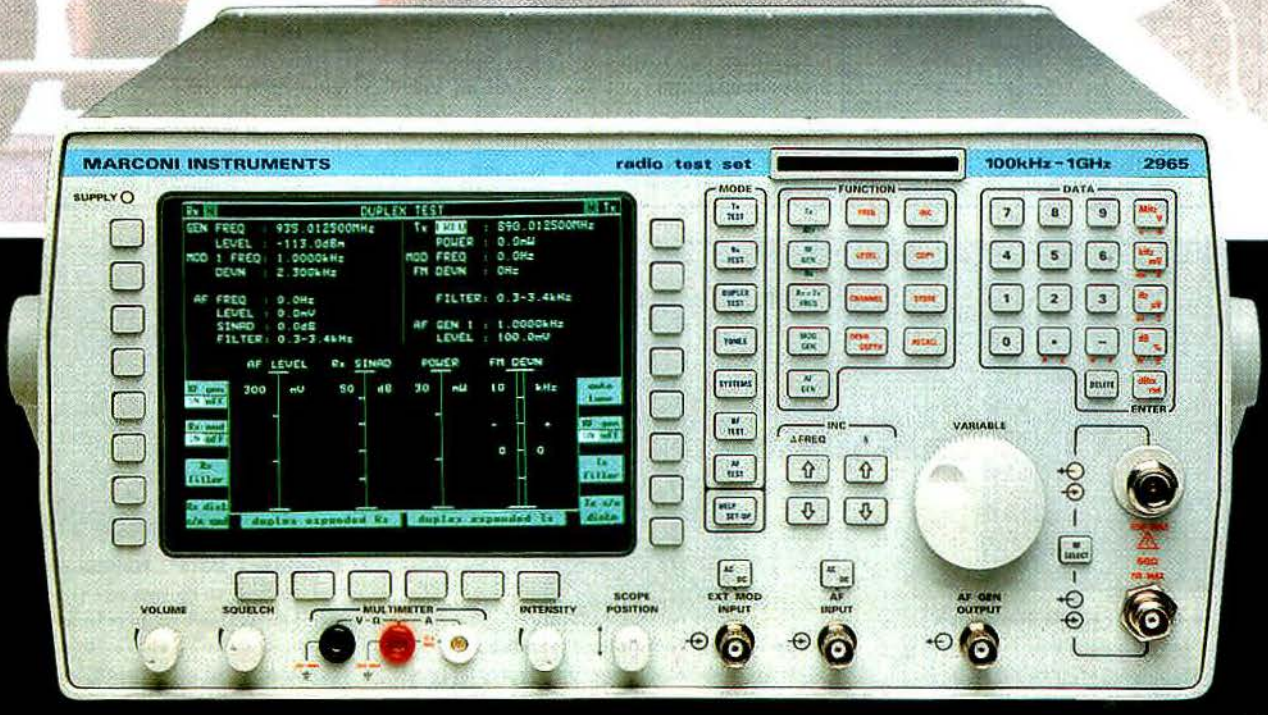

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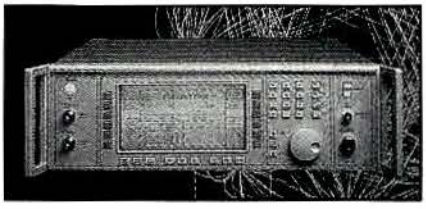
New products

Digital and vector modulation features allow testing during development

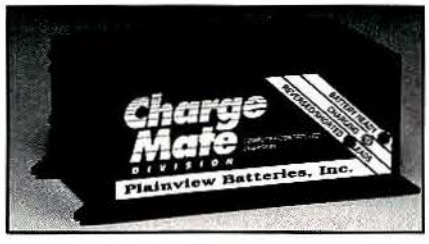


Digital and vector modulation capabilities on the 2050 series signal generators from **Marconi Instruments** allow rigorous receiver testing during research, development and production of equipment for major new digital systems, including NADC, PDC, PHP, CDMA and TFTS. An IQ modulator enables generation of a wide range of modulation formats. A variety of QAM, PSK, broadband AM and spread spectrum signals can be generated. The signal generator also performs Rayleigh and Rician fading simulation for performance testing under typical receiver conditions.

Circle (358) on Fast Fact Card

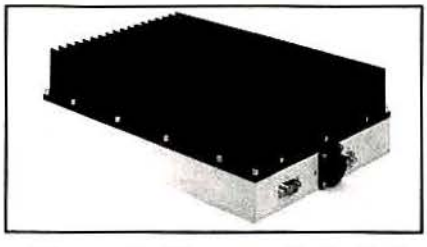
Chargers provide OEMs single, paired options for various battery types

Plainview Batteries offers to original equipment manufacturers (OEMs) its custom-configured, microprocessor-controlled smart chargers singly, or in mated pairs, with assemblies of NiCd, MiMH and SLA batteries for specific applications. The ChargeMate charger pairs range to 30V, and the trickle, standard and fast charge rates range to 300W. All chargers have reverse polarity protection.



Circle (359) on Fast Fact Card

S-band PCS base station amplifier features reverse polarity protection



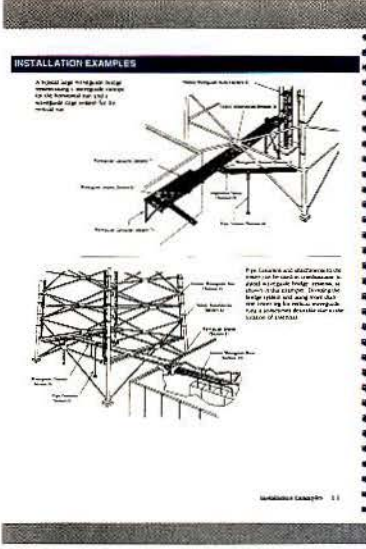
Chesapeake Microwave Technologies offers an S-band, 125W PCS base station amplifier designed for Class A and A/B operation. The amplifier, operating at 1.85GHz–1.98GHz, can be used for OEM applications or for rack-chassis configurations with integral power supplies for operation from 95Vac to 265Vac. The amplifier has reverse polarity protection, over-temperature interlocks and an integral output isolator to ensure safe operation into open or short circuits.

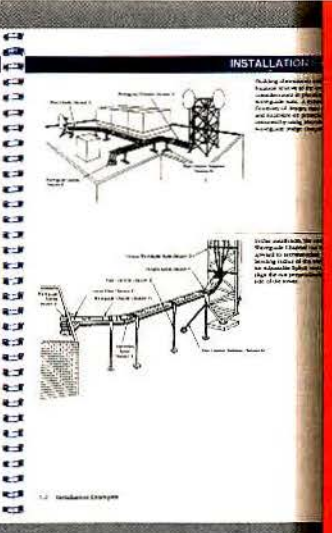
Circle (360) on Fast Fact Card

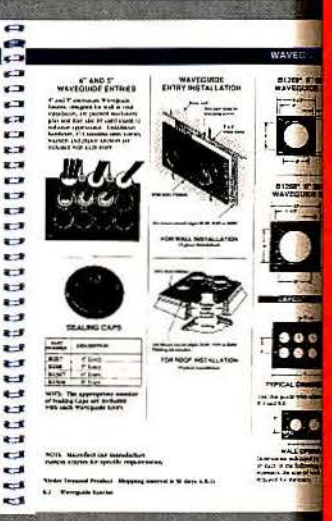
Digital voice log recorder allows simultaneous record and replay

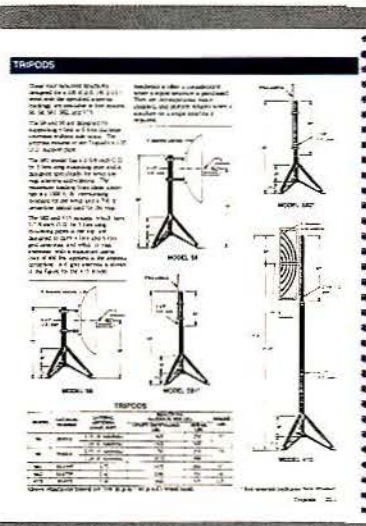
The Rapidax Ranger voice-logging recorder from **Racal Recorders** is a digital system designed for applications including emergency services and fleet dispatch centers. The system allows simultaneous record, access and replay functions and can provide as many as 316 remote positions with spoken-message replay capability. Parallel disk-and-tape data storage includes short-term hard disk storage of as many as 5,000 messages, or 125 channel-hours of speech. For long-term storage, the archival tape system can preserve about 675 channel-hours on one digital audio tape. Security features include password protection and system access monitoring.

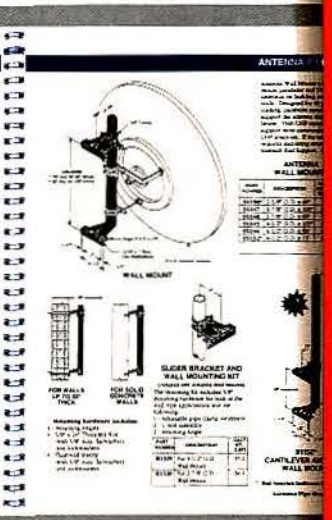
Circle (361) on Fast Fact Card

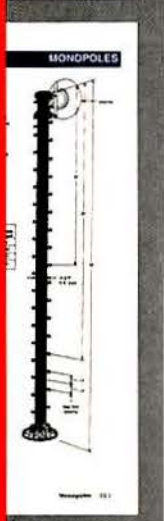


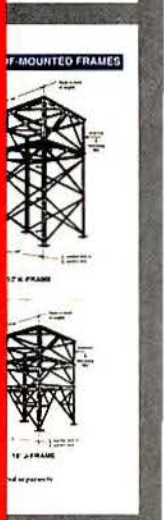












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Circle (69) on Fast Fact Card

New products

Battery replaces Uniden APX1100

Centurion International's model SP1100 7.5V NiCd battery is rated at 1,000mAh. It replaces the APX1100 battery for the Uniden SPS radio.

Circle (362) on Fast Fact Card

Base system offers compatibility with interconnect roaming features

Hark Electronic System's Author! base system is now compatible with the Zetron model 49 push-to-connect roaming feature. The system is also compatible with IDA's roaming feature, and compatibility with SMR interconnects from other manufacturers is in development. This compatibility allows an Author!-based system to automatically receive updates on a roaming mobile's location via existing equipment. One system can support as many as 10 foreign sites per subscriber using automatic roaming or 99 sites using manual roaming.

Circle (363) on Fast Fact Card

Low-loss communications cable features high-flexibility for tight turns

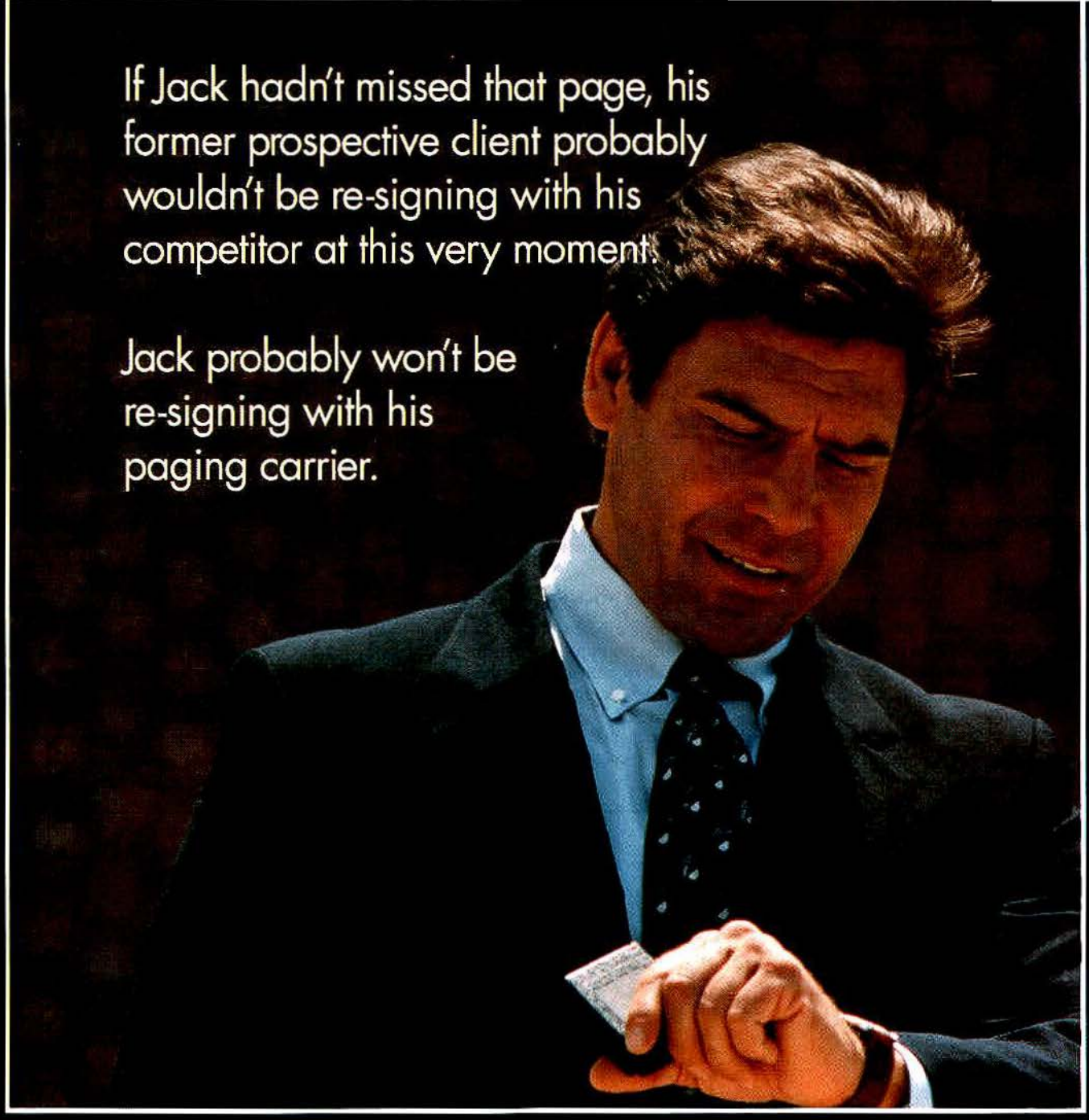
LMR-500 flexible communications cable from **Times Microwave** is a 50Ω impedance, 0.500"-diameter cable providing low loss of 3.13dB/100 feet at 900MHz. The cable provides greater than 90dB RF shielding and phase stability of less than ±10ppm/°C. The cable has a copper-clad aluminum center conductor, a low loss/high-strength polyethylene foam dielectric, a bonded aluminum tape/high-coverage braided outer conductor and a weather-resistant polyethylene jacket. High flexibility gives the cable a minimum bending radius of 1". A UL-listed, fire-retardant version, LMR-500-FR, is available for indoor applications.

Circle (364) on Fast Fact Card

Portable communications console allows mix-and-match of radio makes

The **Nida Companies** Portable Communications Console is available with one to four conventional or trunking radios in any low-VHF, high-VHF, UHF/T and 800/900MHz combination. A Uniden BC-590/760 XLT scanner also can be interfaced. The console has an internal 25Ah SLA battery, an external power supply and a battery level indicator. Nida has interfaced Bendix/King, Icom, Kenwood, Motorola, Standard and Yaesu/Vertex radios in the consoles. Console weight varies from about 43 pounds to 55 pounds, depending on the number of radios. A single-radio shoulder pack with case is also available.

Circle (365) on Fast Fact Card



If you want to maintain good customer relations and expand your coverage area, nothing must come between your paging signal and your clients, like Jack. That's why the Grayson Electronics Division of ATG developed the PageThru® 900MHz repeater. It's the clear solution to overcoming obstructed signals in enclosed structures.

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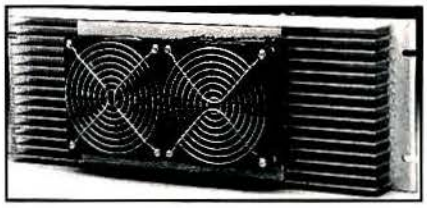
Circle (72) on Fast Fact Card

New products

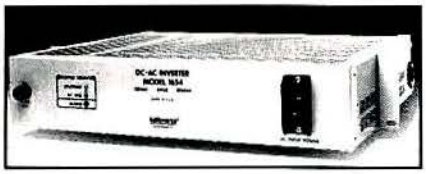
Paging amplifier increases system saturation, compensates for losses



Henry Radio's paging amplifiers compensate for filter/combiner losses and increase paging system saturation. VHF models are rated at 250W–300W continuous output. UHF models produce 180W–220W. Thermostatically controlled fans provide cooling as needed.

Circle (366) on Fast Fact Card

Inverter's regulated output handles difficult loads for sensitive equipment



A compact alternative to bulkier units, the 1654 model rack-mount inverter from **Wilmore Electronics** provides 1,000VA of 120Vac, 60Hz output power from a device only 3.5" high. Standard versions allow operation from 24Vdc, 48Vdc or 130Vdc battery sources. The regulated, frequency-stable, quasi-sinewave output is designed for powering sensitive telecommunications equipment. The inverter is compatible with difficult loads such as switch-mode power supplies, small motors and other nonlinear loads.

Circle (368) on Fast Fact Card

Duplexer allows cellular customers to access wireline, other frequencies

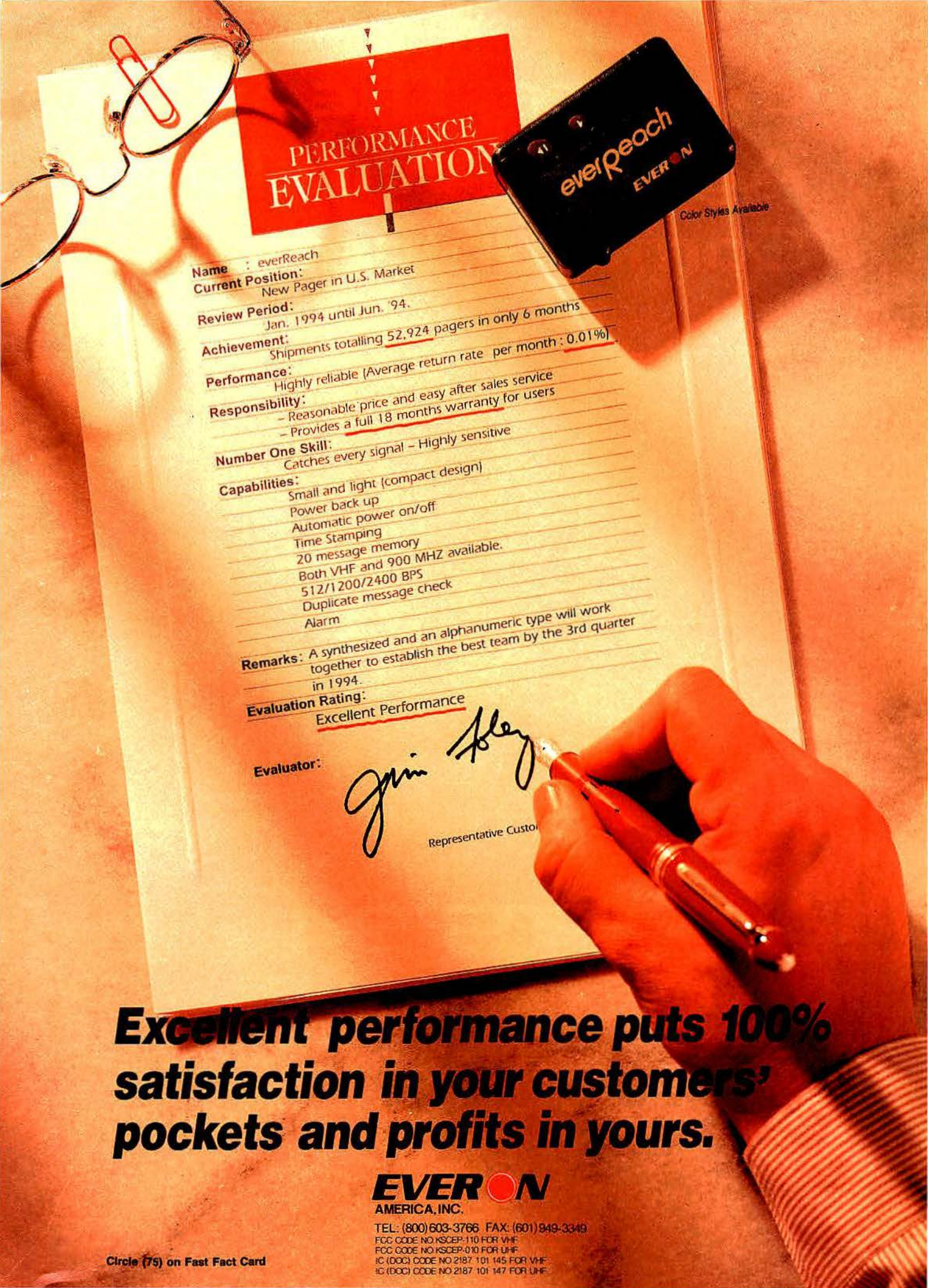
The **Telewave** model TPCD-8928 Combline Duplexer, with a land mobile frequency range of 806MHz–960MHz, is used in cellular master antenna systems to allow customers to access wireline and nonwireline frequencies, AMPS, NAMPS, TACS and ETACS. Maximum input power is 350W with low loss and no harmonic holes. Requiring only one rack space, the duplexer has two compact passband combline filters that ensure rejection of external noise sources. All units are factory-tuned to customer-supplied frequency bands.

Circle (367) on Fast Fact Card

Grounding system alters electrical resistance of surrounding subsoil

The XIT Grounding System from **Lyncole XIT Grounding** provides stable, low-resistance earth grounding regardless of soil type, chemical content or moisture. Atmospheric pressure and wind "pump" air through breather holes at the top of the copper grounding rod. Air moisture contacts a bed of coarse metallic salts and hygroscopically forms droplets of water. The collected droplets form an electrolytic solution that leaches into the surrounding soil and reduces the electrical resistance between the grounding electrode and the earth. The 2"-diameter rods are available with straight shafts or L-shaped shafts for horizontal installation. Custom lengths are available in addition to 10', 12' and 20' models.

Circle (369) on Fast Fact Card



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OCT. 3	10:00-11:45 A.M.	Opening General Session: The Convergence of Technologies. Moderator: Bernard Kalb, CNN		
	Noon-3:30 P.M.	EXHIBITS OPEN		
	12:00-1:30 P.M.	Lunch with Exhibitors in Exhibit Hall (Exhibits Open)		
	1:30-3:30 P.M.	Exhibits Open (cont.)		
	3:30-5:00 P.M.	Fraud	Pioneers Preference	Making It In Corporate America
	5:15-6:30 P.M.	CDPD	Standards	Batteries
	6:30-7:30 P.M.	Social Event		
OCT. 4	7:30-8:30 A.M.	Continental Breakfast		
	8:30-10:00 A.M.	Intelligent Networks	Wireless Applications	Wireless Data
	10:00-10:20 A.M.	Coffee Break		
	10:20-11:50 A.M.	Seamlessness	Microwave Displacement	PDAs
	Noon-1:30 P.M.	Luncheon with Guest Speaker: Michael W. Reene, IBM Consulting Group		
	1:30-6:00 P.M.	EXHIBITS OPEN		
	5:00-6:00 P.M.	Cocktail Reception at Exhibit Hall (Exhibits Open)		
OCT. 5	7:30-8:30 A.M.	Continental Breakfast		
	8:30-10:00 A.M.	Wireless LANs, Microcells & In-Building Coverage	Regulatory	Selling Digital
	10:00-10:20 A.M.	Coffee Break		
	10:30 A.M.-Noon	Closing General Session: Wireless Projections—The Price of Convergence		
	Noon	Grand Prize: Mobile Office Giveaway (MUST BE PRESENT TO WIN)		

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Literature

Catalog showcases tone signaling products

A 28-page color catalog from **Vega** contains descriptions of tone-remote or dc-remote control consoles, remote station adapters, DTMF encoders and decoders and a wide variety of system modules (line termination cards, summing amplifiers, line drivers, single-tone encoders and decoders, notch filters and relay cards). Several new products, including some communications consoles, are described in the catalog.

Circle (300) on Fast Fact Card

Guide covers tower lighting controls

A 16-page application and product selection guide has been expanded to include lamp outage and beacon flasher monitoring relays. The guide from **SSAC** cross-references products and applications. Included are controls for beacon flashing, synchronous flashing of beacons, dusk-to-dawn operation (photoelectric control), lamp outage and failed flasher alarm modules and three-phase voltage (phase loss) monitors. Each data sheet contains complete specifications and typical connection diagrams.

Circle (301) on Fast Fact Card

Book provides insights into scanning

Emergency Radio! Scanning News As It Happens by Norm Schrein provides real-life, action-oriented insights into listening to a broad array of emergency radio communications services, including police, special weapons action team (SWAT), fire department, emergency medical and disaster response communications. Available from **Index Publishing Group,** the 214-page book offers practical guidance on how to monitor radio communications.

Circle (302) on Fast Fact Card

Brochure discusses electromagnetic analysis service

"The Unseen Force" discusses electromagnetic fields and the results such invisible interference can have. The brochure details a service that **Lindgren RF Enclosures** performs, consisting of a complete on-site analysis of electromagnetic levels, a thorough evaluation, and the design and installation of a shielding solution if a problem is identified.

Circle (303) on Fast Fact Card

Guide focuses on fiber-optic transmitters

A four-page product use and selection guide from **Ortel** includes photos, specifications, technical diagrams and applications for standard and specific application cellular radio fiber-optic transmitters and high dynamic range fiber-optic transmitters. These transmitters can be deployed to provide coverage in exhibition halls, stadiums, airports and canyons and to increase system capacity in congested locations.

Circle (304) on Fast Fact Card

Flyer introduces path loss measurement system

A flyer introducing the PathTraxx path loss measurement system for wireless communications networks is available from **Chesapeake Microwave Technologies.** The flyer briefly defines how signal strength and path loss data gathered by the PathTraxx can improve development of wireless communications networks, cellular phone systems and shielded rooms and enclosures. The flyer outlines the operating parameters and specifications of the transmitter and receiver, the two basic components of the system.

Circle (305) on Fast Fact Card

People

Ken Anderson leaves Shannon Data and Display, Atlanta, as sales and marketing manager to join Ora Electronics, Chatsworth, CA, as national sales manager.

James W. Vodak exits Centel, Chicago, as vice president of corporate communications to become vice president of corporate communications for Telular, Buffalo Grove, IL.

Changes at Ericsson, Richardson, TX:

Bo Hedfors, president of Ericsson Network Systems, Richardson, takes on additional responsibility as president of Ericsson GE Mobile Communications, Research Triangle Park, NC, replacing **Ronny Lejdemalm.** Lejdemalm is serving as an adviser to Hedfors until Oct. 1, when he will leave the company. Hedfors also becomes president of Ericsson North America, Richardson, replacing **Leif Kallen.** Ericsson North America will be restructured by merging Ericsson Network Systems and subsidiary units into one organization. Kallen becomes chairman of The Ericsson Corporation, Washington, DC.

Joseph Hagan, a vice president of Ericsson GE Mobile Communications, receives additional responsibility as general manager of the Ericsson facility in Research Triangle Park.

Dr. George Fath, vice president of Ericsson GE Mobile Communications and general manager of its land mobile radio division, receives additional responsibility as general manager of the Ericsson facility in Lynchburg, VA.

Gene Johnson exits Vega as sales manager for the signaling products group to rejoin Kennedy Engineering, Rowland Heights, CA, as vice president of sales.

Letters from readers

Technician licensing:

I read your editorial in the May 1994 issue, and I'm impressed that someone finally recognizes the many problems caused by eliminating the requirement for technicians to have FCC-issued licenses.

When the issue of dropping license requirements was first discussed, I was strongly against it. I am very much against government regulation; however, I could easily see that unless a government agency was going to be responsible for the licensing, the industry would soon be in much trouble. I believe this has come to pass.

Some of the big "pushers" to drop government license requirements were supposed to be "spokesmen" for the industry, i.e., NABER. I understand their position, as it became lucrative for them to issue their own licenses, the value of which is questionable. Another big pusher was the broadcast industry "read that as big bucks lobby." Why should they pay a licensed broadcast engineer $15–$20 an hour when they could pay a disc jockey $5–$10!

Well, it's come back to haunt us all. Unlicensed or otherwise illegal operations are rampant. Using equipment that is not type accepted for the service in which it is being used (amateur and Marine equipment being used for Part 90 operations) and equipment being operated out of tolerance (off frequency and over modulating) are problems that have mushroomed.

I suggest that we return to the FCC-issued license requirement. I would prefer the older 1st and 2nd class type licenses, but I would agree to the general type license as well. Some thought should be given to licensing the shop rather than the individuals working in the shops if this would be more efficient to administer.

While I'm venting my frustrations, I should include the FCC enforcement actions. The FCC has been diligently going after licensees on towers requiring lighting. This action is fine, but it does nothing for the communications industry. It is enforcing laws designed to help the FAA. A proportionate amount of enforcement should be directed at the communications industry. Maybe the FAA should enforce its tower lighting laws so that more of the FCC's budget could be directed toward cleaning up areas that directly affect the communications industry.

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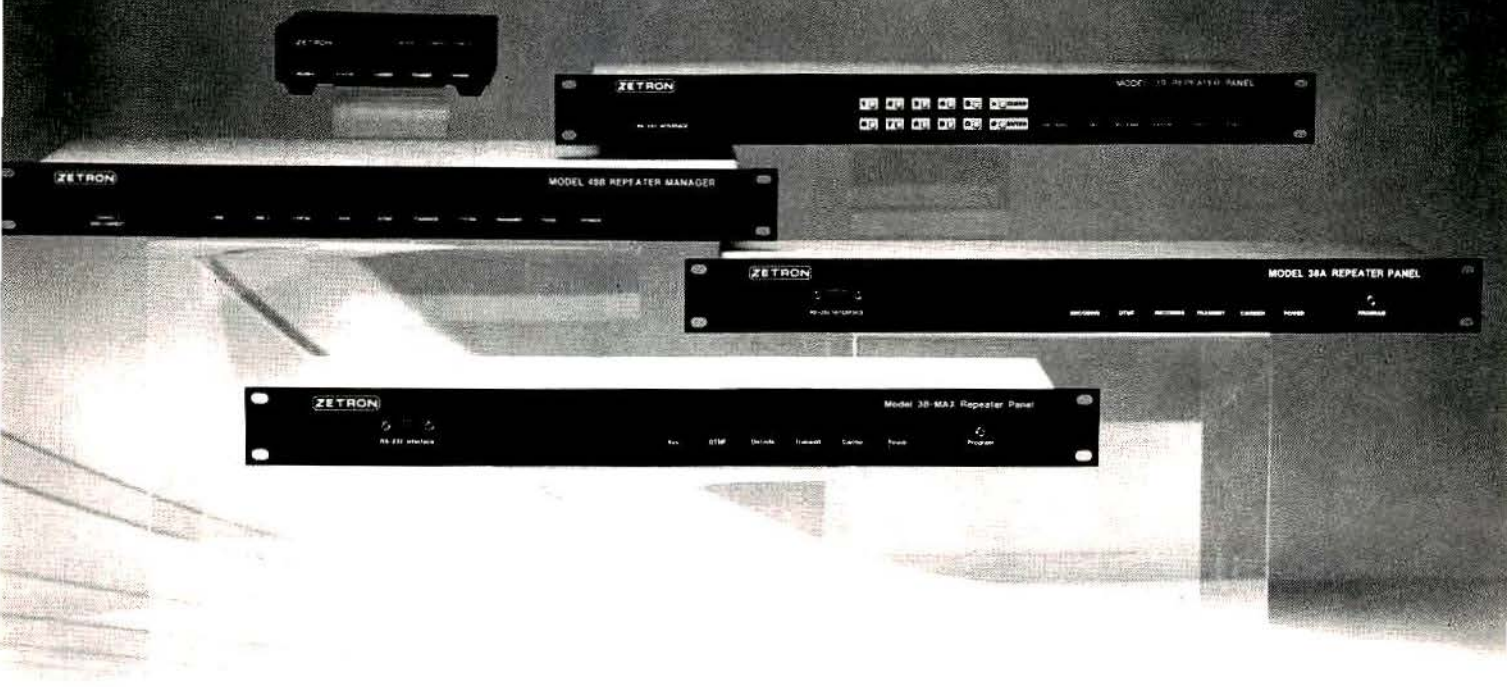
Tone Panels That WORK



A hardworking tone panel should decode a CTCSS/DCS signal even when the radio moves into a fringe area. It should prevent a noisy squelch tail when a user releases the PTT button. Technical problems should be nonexistent. In other words, a tone panel should WORK !

All five models of Zetron's tone panels are equipped with ToneLock, a pioneering decoding circuit that holds onto a weak CTCSS/DCS even if the signal drops below 4dB SINAD. Squelch tails are eliminated before they begin, using rapid CTCSS reverse-burst detect and DCS turn-off codes. Excellent engineering means reliable performance. (How well does your current system work?)

Don't work on your tone panel. Let it work for you.

Model 38-MAX Repeater Panel
High capacity 160 user groups (50 CTCSS, 110 DCS) for scan-based trunking systems or other applications that require numerous tones/codes. Airtime graphs (viewed on PC or hardcopy) reveal channel's tone/code distribution.

Model 48B Repeater Manager
Full-featured community panel with two-line, multi-user telephone interconnect and selective calling.

Model 39 Premium Panel
Handles up to 160 user groups simultaneously and provides a convenient, front-panel keypad and LCD.

Model 38A Repeater Panel
Most popular tone panel in the industry. Includes RS-232 programming and 38 CTCSS/22 DCS.

Model 37 RepeaterMan
Two CTCSS tones for small systems. Can be used with two radios as a "repeater maker."

Zetron Inc. 12335 134th Ct. N.E. Redmond WA 98052 ZETRON® Ph: (206) 820-6363 Fax: (206) 820-7031

Circle (82) on Fast Fact Card

Professional services

Professional Consulting Services

Circle (95) on Fast Fact Card

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Joyce Bollegar
Classified Sales

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Overland Park, KS 66212

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Proficient with Motorola CentraCom I/II and CRT Consoles. Trunking experience is a must. Candidate must have a working knowledge of Motorola RSS software. Requires the ability to troubleshoot large complex systems and repair to component level.

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Proficient with state of the art microprocessor controlled radios. Must be experienced with repair of surface mount components. Candidate must have a working knowledge of Motorola RSS software and trunking.

Must be willing to work in a participative team environment and dedicated to the concept of Total Customer Satisfaction.

Please respond to:

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Motorola Communications
1111 W. Evans, Suite C
Denver, CO. 80223
(303) 922-6686 (303) 799-3928 fax

New Mexico
Cliff Barbieri
Motorola Communications
1001 Candelaria NE, Suite A
Albuquerque, NM 87107
(505) 343-3145 (505) 345-0809 fax

TWO WAY RADIO TECHNICIAN

Motorola Pinnacle Dealer and Service Shop looking for self motivated and highly qualified technician. Working knowledge of all Motorola equipment, especially Motorola 800 MHz trunking systems (both fixed & mobile). Salary Commensurate with experience, Complete Benefits Package, Paid Vacations & Holidays. Send resume & comments to:

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Salary commensurate with experience, with a complete benefits package, paid vacations and holidays. Send resume with salary requirements to:

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1819 N. University Ave., LUBBOCK, TX 79415
ATTN: PERSONNEL DEPT.

Motorola MSS in Florida Panhandle

looking for senior bench/field tech. Successful candidate will possess 5 years or more experience; FCC or NABER certification; proficiency in installation and repair of microwave, Motorola SMR, paging, Centracom II; excellent customer skills. Excellent pay and benefits. Send resume to:

Attn: MRT, Dept #934
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Overland Park, KS 66212.

Burns & McDonnell, consulting engineering firm, has excellent opportunity for a telecommunications engineer with 3-7 years electric utility experience. Contact **Mr. M. R. Rice, P. O. Box 419173, Kansas City, MO 64141 (fax 816/822-3413), EOE.**

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The Missouri Department of Conservation has a position available for an experienced electronics technician at our West Plains Headquarters. West Plains is a rural city located in southern Missouri and offers a low cost of living. This position maintains telecommunication systems including component level troubleshooting and repair, installation, and removal of base stations, mobile and portable radio units. Knowledge of PBX and electronic key telephone systems preferred. Requires an electronics technical school certificate and a minimum of three years experience in repair and maintenance of electronic equipment including two-way radio, office telephone systems and data communication networks. Salary will be mid to high twenties depending on experience. Excellent benefit program. **To apply contact the Human Resources Division, Missouri Department of Conservation, P.O. Box 180, Jefferson City, MO 65102 (314/751-4115).** Call between 8:00 a.m. to noon or 1:00 p.m. to 5:00 p.m.

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Advanced Signal has received a FLEX™ license from Motorola to develop an innovative test and monitoring instrument. The product will be used by paging system operators to read, decode and capture FLEX™ data streams for analysis.

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Must have an administrative background plus 1-3 years' network planning experience (DC power systems, antennas, patch bays, transmission equipment) or 3-5 years of experience troubleshooting cellular/telco systems.

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You will work on-site with our clients, with responsibility for coordinating company installation resources and customer requirements; acquisition and management of warehouse facilities for storage; tracking repair and return items; management of change orders, budget and schedules for the market and various local support personnel; and customer interface.

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Application Engineers
Will support sales staff by making technical, product and system benefit presentations to customers; support proposal preparation; and perform analysis, define systems configuration, and provide proposal documentation. U.S. cellular experience required.

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We seek dynamic sales professionals with 3-5 years of systems sales experience (switching, networks), preferably to large telco operators. Previous cellular network sales experience is a must. Territory is the Southeastern U.S. Home base is open.

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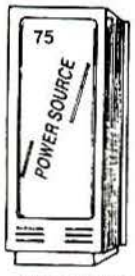

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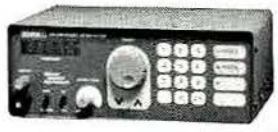

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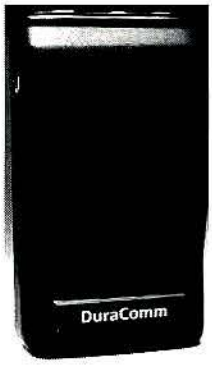

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25 ea. Syntor X, 800MHz, T45VBJ5G11	
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12 ea. Motrac Rptrs, 460 MHz, C24MSY3101T	
17 ea. Mitrek, 460 MHz, T74JJA3100	
5 ea. Maxar 80, 460 MHz, D34TSA3000	
10 ea. MX340, 460 MHz, H44AAU3140	
34 ea. MT500, 460 MHz, H34BBU3124	
8 ea. HT440, 460 MHz, H44LCU3144	
8 ea. Micor Bases, 153 MHz, C73RTB1106	
4 ea. Consolette Bases, 153 MHz, L43BBB3000	
33 ea. Syntor, 155 MHz, T83SRA3200	
46 ea. Mitrek, 153 MHz, T83JJA3900	
91 ea. Micor, 153 MHz, T73RTN3100	
5 ea. Maxar 80, 153 MHz, D63TSA3300	
1 ea. Consolette Base, 35 MHz, L51BBB3400	
22 ea. Mitrek, 47 MHz, T81JJA4900	
8 ea. Mitrek, 48 MHz, T51JJA4900	
5 ea. GE Mastr II, 48 MHz, MC74CCS33	
9 ea. MASTR EXEC II, 48 MHz, SX74AAN33AH	
2 ea. MT500, 47 MHz, H31BBU3100	
60 ea. Tone and DC Remote Desk Sets, Mixed Models: T1380, T1376, T1902	
66 ea. Syntor X 9000 Control Heads, HCN1033A	
4 ea. CENTRACOM I Single Bay Tone Remote, MCM w/T&R Modules	
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100 Sets Motrac Accessories	
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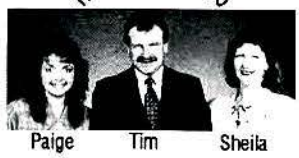

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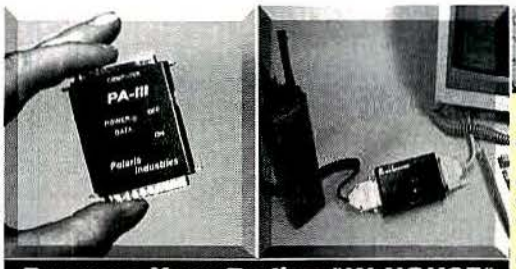

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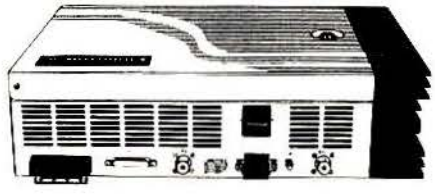

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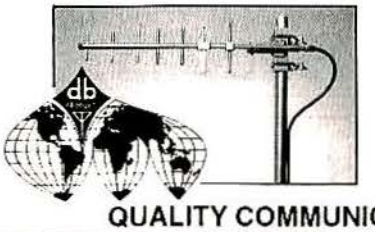

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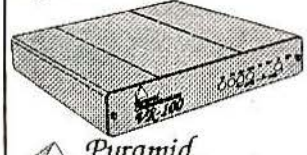

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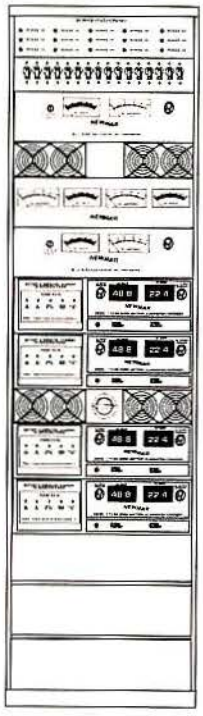

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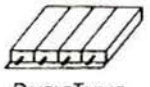

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E Trunk Systems, Inc.	89	105	914-245-1128
Everon America, Inc.	75	75	800-603-3766
Fourth Dimension	91	110	516-467-1220
Frequency Management	92	113	800-800-9825
GLB Electronics	62	59	716-675-6740
Haewa Corporation	66	84	800-783-4239
Henry Radio	66,91	64,111	800-877-7979
Hewlett Packard	37	30	509-921-4001
Hustler, Inc.	43	36	800-949-9490
Hutton Communications	12	9	800-442-3811
Hy-Q International	93	118	606-283-5000
ICT Systems, Inc.	82	80	800-779-1917
IFR Systems, Inc.	53	46	316-522-4981
Interactive Systems, Inc.	72	71	703-812-8270
ITC Instruments	65	63	800-566-1818
JBRO Batteries, Inc.	67	65	800-323-3779
KNS Electronics, Inc.	82	81	408-432-8100
Larsen Electronics	29	23	800-426-1656
Lazer Beepers, Inc.	100	134	800-354-3405
Leathersmith	60	57	800-233-0440
LeBLANC	15	12	214-934-1894
Lett Electronics Co.	88	100	800-521-2468
Marconi Instruments	69	67	800-233-2955
Maxrad, Inc.	IBC	2	800-323-9122
McManus Communications	88	101	501-763-6250
Mechem Electronics	93	115	703-373-3888
Megahertz Technology, Inc.	87	97	214-341-0562
Meridian Communications	47	40	818-222-5655
Microflect	71	69	503-363-9267
Midian Electronics, Inc.	41	34	602-884-7981
Midland International LMR	28	22	800-MID-LAND
Modular Communication Systems	44	37	818-764-1333
Motorola C&E	55,102	49,137	708-538-6333
Motorola GPID	13	10	708-538-3000
Motorola Page Care Centers	40,90	33,109	407-364-2966
Motorola Test Equipment	17	14	800-235-9590
MX-COM, Inc.	7	7	800-638-5577
NATCOM, Inc.	81,90	79,107	800-844-8287
NEC America, Inc.	57	52	214-751-7273
New Mar	96	140	800-854-3906
Norton Engineering	97	127	703-938-5745
Orbacom Systems, Inc.	21	17	609-829-4455
Pekaar Communication, Inc.	93	117	201-132-0704
PerCon Corporation	99	132	716-386-6015
Personal Comms Industry Assn	76	76	202-467-4770
Photocomm, Inc.	72	70	800-223-9580
Polaris Industries	92	112	800-752-3571
Polyphaser Corp.	66	83	800-325-7170
Pyramid Communications	95		310-430-5892
Quantum Publishing, Inc.	70	68	415-381-4488
Radio Express, Inc.	89	104	703-266-1928
Radio Wholesale	95	123	800-53R-ADIO
RAM Communications Consult.	84	95	908-636-6970
Ramsey Electronics	89	103	716-924-4560
RCW Distributing	92	114	800-726-9015
Rocky Mountain Comms, Inc.	98		303-526-5454
Santa Fe Distributing	56	50	913-492-8288
Scala Electronic Corp.	80	78	503-779-6500
Schlumberger Technologies	33	27	800-225-5765
Selectone Corporation	51	44	800-227-0376
Sentry Manufacturing Co.	99	131	405-224-6780
Serviceware Corporation	54	48	613-521-7391
Sharp Communication	90	108	800-548-2484
Shinwa Communications of AM	58	54	800-627-4722
Shure Brothers, Inc.	45	38	800-25S-HURE
Softwright	97	125	303-344-5486
Solar Electric Specialties	74	74	800-344-2003
Spacecom Systems, Inc.	5	6	800-950-6690
Stancil Corporation	59	55	714-546-2002
Sti-Co Industries, Inc.	36	29	716-662-2680
Survey Technology	48	41	503-591-5986
Tait Electronics USA, Inc.	38	31	713-984-8684
Talley Communications	42	35	800-949-7099
Telepoint, Inc.	68	66	310-652-3666
Telewave, Inc.	60	56	415-968-4400
Telex Communications, Inc.	27	21	800-554-0716
TGA Systems, Inc.	30	24	404-441-2100
Times Microwave Systems	50	43	203-949-8400
Towerwatch	103	139	913-233-2343
Transcrypt International,Ltd.	3	5	800-228-0226
Transtronics, Inc.	54	47	913-841-3089
Uniden Corp of AM-MSG Inc.	26,49	20,42	817-858-3300
Vega, A Mark IV Company	1	4	818-442-0782
Versatel Communications	93	116	800-456-5548
Vocom/RF Corporation	56	51	800-USA-MADE
Western Multiplex Corp.	74	73	415-592-8832
Wetec Electronics	94	120	901-286-6275
WirelessWorld Conference	78-79	86	913-967-1848
W & W Associates	63	61	800-221-0732
Zetron, Inc.	32,64	26,62	206-820-6363
Zetron, Inc.	83	82	206-820-6363

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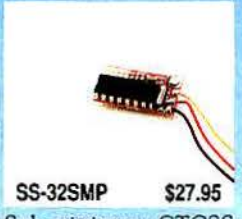

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